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Mariners Weather Log

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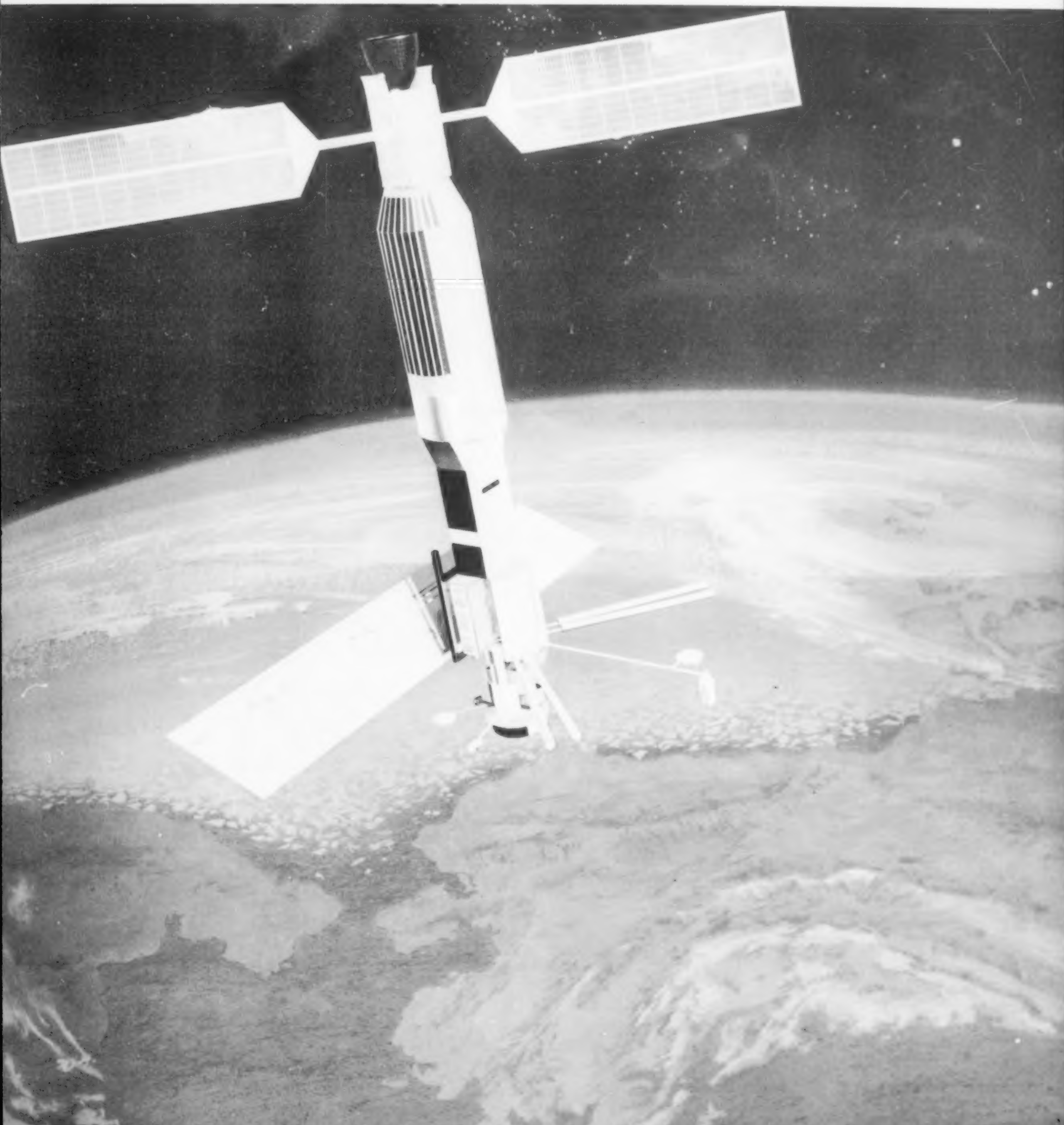

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Mariners Weather Log

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Cover: SEASAT-A cruises over the Bering Sea. When this satellite becomes operational, the marine environmental products available to mariners should increase substantially. See article on page 355.

Routing
Master __________

Observing Officers
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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget through June 30, 1980.

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Mariners Weather Log

SEASAT-A AND NIMBUS G

APPLICATIONS TO MARINE WEATHER

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INTRODUCTION

The SEASAT-A and NIMBUS-G research satellites are scheduled for launch by the National Aeronautics and Space Administration in May and August to October 1978, respectively. SEASAT-A in its 109° inclination, 800-km altitude, nonsun-synchronous orbit carries five sensors specifically designed to make oceanic measurements. SEASAT-A will carry also a laser retroreflector and tracking beacons for precise orbit determination. NIMBUS-G carries two sensors for marine applications in its 955-km altitude, 99.28° inclination, Sun-synchronous orbit, which has a 1200 hr ascending local mean solar time equatorial crossing. The nonoceanic instruments on NIMBUS-G include the Earth Radiation Budget (ERB) radiometer, the Limb Infrared Monitoring of the Stratosphere (LIMS) sensor, Stratospheric Aerosol Measurement (SAMII) sensor, the Solar and Backscatter Ultraviolet/Total Ozone Mapping Systems (SBUV/TOMS), and the Temperature-Humidity Infrared Radiometer (THIR).

Both satellites will carry an identically designed Scanning Multichannel Microwave Radiometer (SMMR) so that a total of six oceanic research sensors will be available in 1978. Three are active microwave sensors, all on the SEASAT-A spacecraft, which transmit electromagnetic energy to the sea surface and measure the reflected signal. Two sensors operate in the visible and infrared regions of the frequency spectrum with a Visible and Infrared Radiometer (VIR) on SEASAT-A and a Coastal Zone Color Scanner (CZCS) on NIMBUS-G. The former is provided for feature identification, and the latter primarily to provide marine biological data.

SENSOR AND DATA CHARACTERISTICS

The characteristics of the sensors are described in terms of the geophysical performance anticipated. Attention is directed primarily to the microwave sensors, as these instruments will have the greatest potential impact on marine weather improvement, although the marine community will benefit from all the oceanic sensors.

The VIR instrument on SEASAT-A is identical to the Scanning Radiometer (SR) on the current NOAA polar-orbiting series, except for modification due to altitude differences. Its two channels in the visible and thermal infrared will provide for day-night feature identification of clouds and major water masses contiguous in time with the microwave observations. The total swathwidth exceeds all the microwave sensors with a total width of more than 2,200 km.

The NIMBUS-G CZCS characteristics have been chosen specifically to measure the chlorophyll in the ocean. Six channels are provided by CZCS, with four having a high spectral resolution of 20 nanometers (nm) (one billionth of a meter) centered at wavelengths of 443, 520, 550, and 670 nm. The two remaining channels, one from 700 to 800 nm and the other from 10.5 to 12.5 micrometers (μm) (one millionth of a meter), are designed to provide sea surface and land interface effects and sea surface temperature, respectively. The surface resolution is approximately 825 m, and the total swathwidth exceeds 1,500 km. The scanner mirror can be tilted in 2° increments forward or backward through ± 20° with respect to nadir about the NIMBUS-G pitch axis.

As noted, both satellites will carry the SMMR sensor operating at frequencies of 6.6, 10.7, 18, 21, and 37 GHz. The spatial resolution ranges from about 100 km at 6.6 GHz to 22 km at 37 GHz. The three primary classes of data obtained from the SMMR are sea surface temperature (SST), sea-ice mapping, and surface winds. Liquid water and water vapor are potentially measurable and will be used to formulate pathlength attenuation corrections for the altimeter and scatterometer. SST is to be measured to ± 2°K (kelvin), an important first step to determining SST under cloudy sky conditions. The magnitude of the surface winds will be measured to ± 2 m/sec or 10 percent, whichever is larger, from 7 m/sec to about 40 to 50 m/sec. The SEASAT-A SMMR will scan the starboard side of the spacecraft, aft-viewing, with a constant 42° angle from nadir. The scan angle is from about 0° to 50° resulting in a swathwidth of about 650 km. The NIMBUS-G SMMR will also scan at a constant 42° angle from nadir but will look forward and scan ± 25° with respect to the groundtrack. The resulting swathwidth is about 725 km. The 42° angle from nadir for both SMMR systems gives a constant 45° angle of incidence at the surface. The SEASAT-A SMMR coverage was chosen for maximum overlap with the scatterometer sensor.

The SEASAT-A Scatterometer System (SASS) is an active microwave instrument which illuminates the sea surface with four fan-shaped beams (two ortho-

gonal beams each about 750 km wide on each side of the SEASAT-A groundtrack). The amount of energy returned provides an estimate of surface wind magnitude and direction. The transmitted frequency is 14.6 GHz with the returned energy shifted slightly due to doppler effects. The doppler shift aids in establishing a spatial resolution of 50 km over a region from 250 to 750 km on either side of the spacecraft. Surface winds will be determined to ± 2 m/sec or 10 percent, whichever is larger, in magnitude and ± 20° in direction. With less precision, the SASS can measure winds out to 1,000 km from the spacecraft. The range of winds to be measured is 3 to 25 m/sec.

INSTRUMENT POINTING (DEGREES)

	CONE	CLOCK	FOV
ALT	0	0	1.5 CIRCULAR
SAR	20.5	90	±3 CONE
SASS	0-7, 19.5-55	45	± .25 CLOCK
	"	135	"
	"	225	"
	"	315	"
SMMR	42	133-183	±2 CONE
VIRR	51.38	90, 270	± .15 CLOCK

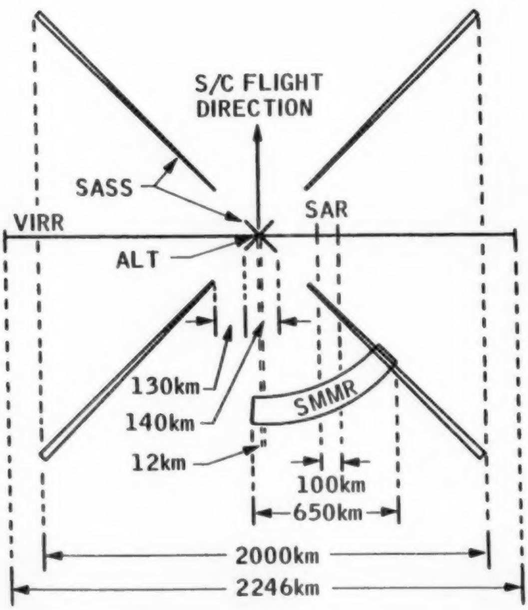

Figure 1.--SEASAT-A sensor coverage sketched to scale along the groundtrack of the satellite. The "Cone" refers to the point angle of the sensor, "Clock" refers to the clockwise angle from the direction of flight, and "FOV" (field of view) could be referred to as the total beam width.

A short-pulse (3 nanoseconds) radar altimeter, operating at 13.5 GHz frequency, was the first instrument selected for SEASAT-A. Because the sensor looks only at nadir, the orbit of SEASAT-A has been tailored to support the geodesy requirements of the altimeter. Its swathwidth is between 1.8 and 12 km, depending upon sea state. The precision of the altimeter measurement is expected to be 10 cm root mean square over seas with a significant wave height from calm to about 20 m. Precise spacecraft tracking is needed for geodesy, currents, and storm-surge analyses. Processing of the altimeter pulse will yield an estimate of significant wave height to ± 0.5 m or 10 percent, whichever is larger, over seas from calm to 20 m.

The L-band (1.275 GHz) Synthetic Aperture Radar (SAR) will look to the starboard side of SEASAT-A centered 20° off nadir with a swathwidth of 100 km. The length of the track is determined by the receive-station-view duration with 4,000 km the maximum. A spatial resolution of 25 m needed for wave analyses will generate a very high data rate so that on-board recording will not be used. Thus, data will be collected only within view of Merritt Island, Fla., Goldstone, Calif., and Fairbanks, Alaska. Waves and wave spectra to oceanic wavelengths of 50 m or greater can be measured with SAR, along with sea-ice features, possible iceberg detection, wave-land interfaces, and penetration to the surface through major storms such as hurricanes.

The geometry of the SEASAT-A sensors is shown in figure 1, which illustrates the several swathwidths that are asymmetrical about the groundtrack. Data from the microwave sensors will be recorded on board and telemetered to one of the receiving stations, except the SAR data, which can only be transmitted directly. Hence, global coverage is from three of the four microwave instruments on SEASAT-A and the SMMR on NIMBUS-G.

The SEASAT-A instrument ensemble will provide 95-percent global coverage in 36 hr for surface winds, temperature, and waves. NIMBUS-G is comparable. The spatial resolutions associated with each instrument in the description above may be viewed in a different manner when coupled with the swathwidth and

Table 1.--Equivalent SEASAT-A data reports per day

Parameter	Real time	Nonreal time
Winds		
Vector-SASS	115,000	192,000
Magnitude-SMMR* (every 50 km)	106,000	177,000
Waves		
H1/2-Altimeter (every 6.7 km)	36,000	60,000
SST		
Temperature-SMMR*	46,000	77,000

*The SMMR data shown are approximately doubled if the data from NIMBUS-G and SEASAT-A are combined.

orbital velocity to define an equivalence with regard to ship and buoy data.

These equivalencies are given in table 1 for near instantaneous spatial averages rather than point source data temporally averaged. The significant increase in data availability illustrates the importance of both the satellite technique and maintaining and improving the conventional collection methods. Rigorous calibration of the satellite requires the existing surface ship marine program, and that program's capability is extended spatially by satellite.

Real-time data will be processed by the Navy Fleet Numerical Weather Central, Monterey, Calif., and will be received and retransmitted from Fairbanks, Alaska. The nonreal-time data will be processed by the Jet Propulsion Laboratory in Pasadena, Calif.

SEASAT-A and NIMBUS-G marine data will be archived and distributed by the Environmental Data Service (EDS) of NOAA. Data with about a 12-day delay from time of acquisition can be obtained from EDS in September 1978 for SEASAT-A. Initial data may be quite limited geographically. After launch there will be at least a 3-mo process-proving period in which the sensor electrical units are converted to geophysical units. When the research data are ready, they will be available on a user-reimbursable basis from the Satellite Data Services Branch, Environmental Data Service, NOAA, Washington, D.C. 20233.

A special comment on the availability of SAR data is appropriate. Current plans are to collect data from 400 to 1,500 orbits during the first year of SEASAT-A operations. Of these orbits, 260 10-min passes (2,600 min of data) will be processed to imagery the first year. Thus, while the other sensor data will be widely available to the marine community, SAR data will be quite limited.

APPLICATIONS

The sensors described above will provide data to many marine disciplines. Tables 2 and 3 summarize the anticipated applications. Those measurements explicitly related to marine weather forecasting and improvements, including winds, waves, and ice, are described below.

Table 2.--Marine applications of SEASAT-A and NIMBUS-G microwave data

Research	
Coastal Region and Lakes	Open Ocean
Shallow water waves	Surface winds/stress
Internal waves	Wave spectra
Circulation processes	Surface temperature
Storm surge and setup	Currents
Near shore winds	Atmospheric water vapor
Shoals	Tides
Oil spills	
Lake Ice	
Geodesy	Polar (Sea Ice)
Geoid	Dynamics
Precise ephemeris	Mapping
	Statistics
Demonstration	
Meteorology	Oceanology
Data validation	Wave forecasting
Global models	Sea ice chart improvement
Boundary layer winds	Wave model application
Living Marine Resources	Geodesy
Wind/plankton studies	Geoid comparisons
SST/fisheries	Oceanic tides/sea level
Surface layer transport	

Table 3.--NIMBUS-G CZCS radiance measurement applications

Water Mass Dynamics	Bio-Optical State
Processes	Chlorophyll concentration
Discrimination	Primary productivity
Identification	Temperature/chlorophyll relationships
Classification	Insolation
Parameters	
Suspended particulates (turbidity)	Environmental Quality
Temperature	Natural
Surface roughness	Water clarity
Circulation	El nino
Transport	Red tides
Surface currents	Man made
Upwelling	Pollution
	Detection
Ecosystem	Tracking
Carbon fixation	Photosynthesis
CO_2 capture/release	Degradation
Energy balance relationships	
Living Marine Resources	Bathymetry
Year-class potential	Not generally applicable
Larvae transport	
Temperature	
Food	
Model evaluation	
Efficiency of operations	

Surface Winds--Measurement of surface winds by microwave remote sensing depends directly on the relationship between the oceanic capillary wave structure and the winds. Surface winds can be inferred from the amount of microwave energy either reflected and/or emitted by the capillary wave scattering of the ocean's surface. Any dependency of capillary waves on water and air temperature (stability conditions), surface contaminants (oils of both biological or petroleum origin), gravity waves, and surface currents interferes with the microwave measurement of surface winds. The surface wind has normally been defined as the wind at the 19.3-m level for the majority of remote sensing experiments.

The SMMR instrument on both satellites and the SASS instrument are designed to measure surface winds. The former will measure magnitude only, and the latter will measure velocity. The velocity measurement by SASS depends on the amount of energy returned to the sensor in relation to that transmitted. It is defined as the backscattering cross-section or coefficient for a unit area illuminated. Figure 2 illustrates the dependency of the backscattered energy as a function of incidence angle for several windspeeds measured in the upwind direction as from an aircraft. The SASS sensor in orbit covers angles of incidence from about 19° to 55°.

Correlation of the backscattering relationship to surface winds was obtained from the SKYLAB scatterometer system results. Figure 3 shows the measurements in the vicinity of hurricane Ava by SKYLAB. It also illustrates the need to refine the measurement technique in order to provide a more quantitative measurement.

The wind direction influence is shown in figure 4 wherein an aircraft banks at a fixed angle keeping the same surface area of the ocean under observation. The wind velocity is assumed constant over the 2-min interval required for the measurement. Theoretical

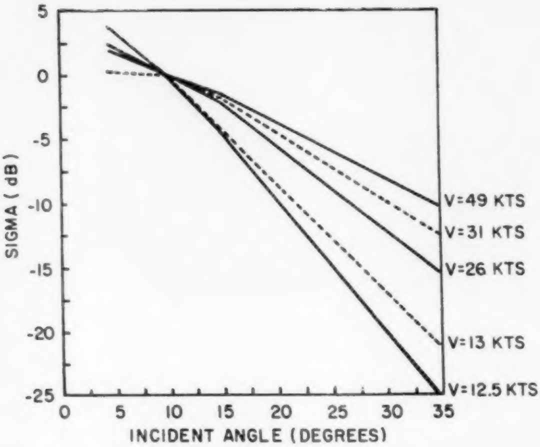

Figure 2.--Backscattering coefficient (σ) at 13.3 GHz as a function of incidence angle normalized to 10° angle of incidence for several upwind windspeeds. Courtesy of W. Guinard, Naval Research Laboratory.

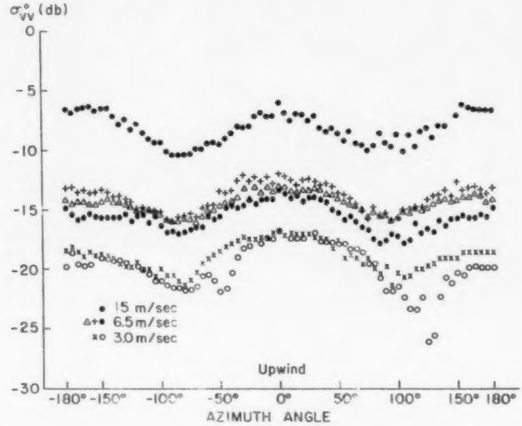

Figure 4.--The effects of wind direction on the backscattering coefficient (σ) at an angle of incidence of 30° (vertical polarization and 13.9 GHz frequency). Courtesy of L. Jones, Langley Research Center.

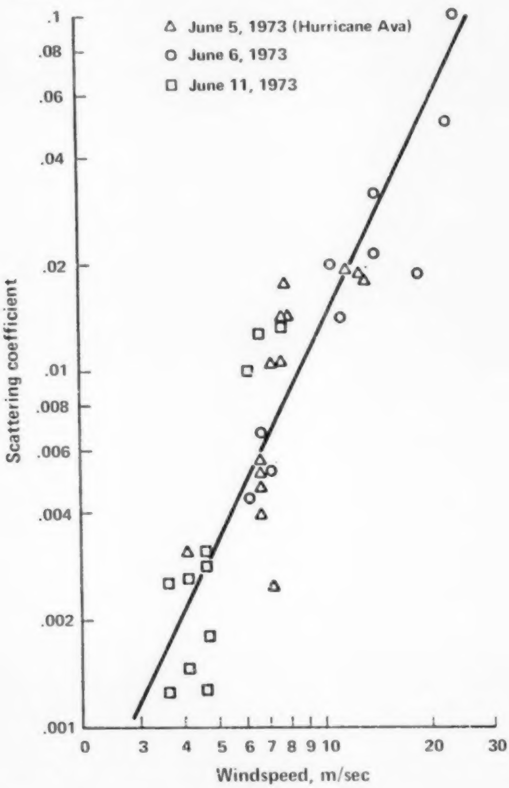

Figure 3.--The SKYLAB S193 Scatterometer (13.9 GHz response to the surface winds of hurricane Ava (horizontal polarization, 50° angle of incidence).

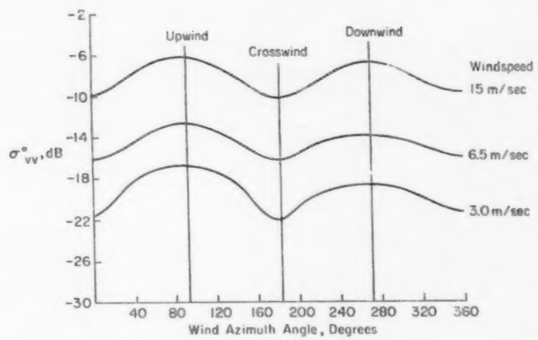

Figure 5.--Model results of the measured data in figure 4, showing that the upwind coefficient is slightly greater than the downwind backscattering coefficient. Note that there is a 4 dB range in the backscattering coefficient for the same windspeed depending on wind azimuth angle. Courtesy of W. Grantham, Langley Research Center.

studies support the effects of wind direction, so that the backscattering cross-section can now be modeled. The model studies indicate that the upwind observation yields a slightly higher backscattering cross-section than the downwind, with the crosswind nulls identical and the differences diminishing as the windspeed increases. Figure 5 shows the results of the model studies. Note that for any given wind direction the backscattering cross-section in decibels (dB) approximately doubles as the windspeed doubles over the interval shown.

Because of the dependency of the backscattered energy on both magnitude and direction, a single observation from the ocean cannot determine surface

wind conditions. The SASS approach is to make two observations of the same ocean surface area from orthogonal directions. Figure 1 shows these two beams on each side of the spacecraft flight track, located 45° and 135° (and the matching beams at 225° and 315°) off the groundtrack.

Even with the two orthogonal beams, the measured winds will have an ambiguity of 180° in direction and possibly several additional biasing values. This aspect illustrates the need to merge the SEASAT-A data with the existing wind-reporting network and wind analyses to take advantage of the satellite-derived data. This again emphasizes the continuing need for timely and accurate ship weather observations over the world's oceans, especially those from data-sparse areas. The gain accomplished by this merger can be the knowledge of global winds as often as every 50 km over a 36-hr period. Multiple satellites could increase the temporal coverage to values more often than every 36 hr, but such a requirement is an operational consideration not required in a research activity.

Surface Waves--Two instruments on SEASAT-A will measure ocean waves with different physical principles. The radar altimeter, looking at the nadir point, transmits a very short pulse to the surface. Because of this short pulse, the rise time of the return signal is quite sharp from a calm sea, but rises more slowly for a rougher sea. The theoretical analysis in figure 6 has been verified with the GEOS-3 radar altimeter. A direct measurement of significant wave height from a fairly narrow swath (about 2 to 12 km, depending on surface roughness) will be made on a global basis with the SEASAT-A altimeter.

The altimeter will not be able to measure the directional properties of waves. The SAR system with 25-m spatial resolution is expected to measure waves as short as 50-m wavelengths. Global coverage will not be possible because of the requirement for direct readout from the three U.S. ground stations, but samples of the wave climate around U.S. waters extending as far as 2,000 km from shore are possible. The relatively low frequency (L-band, 1.275 GHz) of SAR should penetrate the majority of atmospheric conditions, including hurricanes.

An aircraft L-band synthetic aperature radar was flown by the Jet Propulsion Laboratory and the SEASAT-A SAR Experiment Team over hurricane Gloria in September 1976. The results of one flight are illustrated in figure 7. Analysis of the wave patterns is shown in the three samples of this figure and permit both the wavelength and direction of the waves to be specified throughout the vicinity of the hurricane. Such results are important to understand the air-sea interaction in a hurricane and for operational use in warnings to the seafarer when hurricane avoidance is not possible.

Sea Ice--The 72° inclination orbit of SEASAT-A will permit only limited coverage of the polar regions. Nevertheless, significantly high spatial resolution ice data will be collected in the Arctic by the SAR system to complement the lower resolution data collected by SMMR. The NIMBUS-G SMMR system will greatly extend the polar coverage of SEASAT-A due to its 99° inclination orbit. NIMBUS satellites 5 and 6 carried

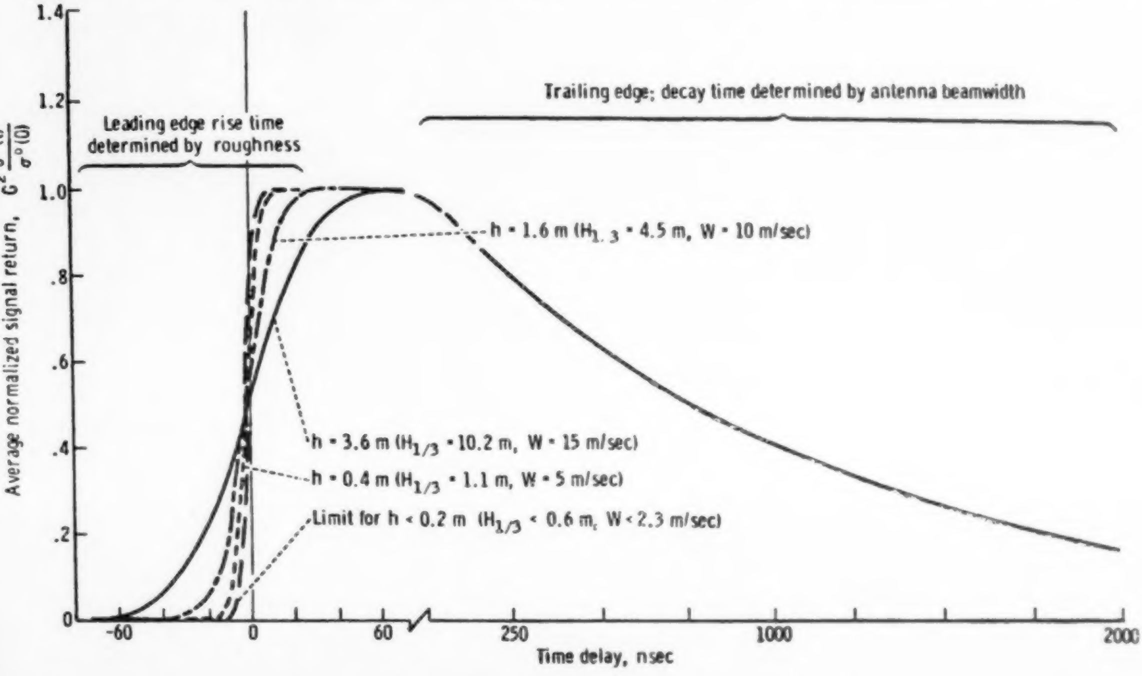

Figure 6.--Average radar nadir backscattering coefficient as a function of rise time, where the time is dependent on sea state conditions ($H_{1/3}$ is significant wave height and W is windspeed).

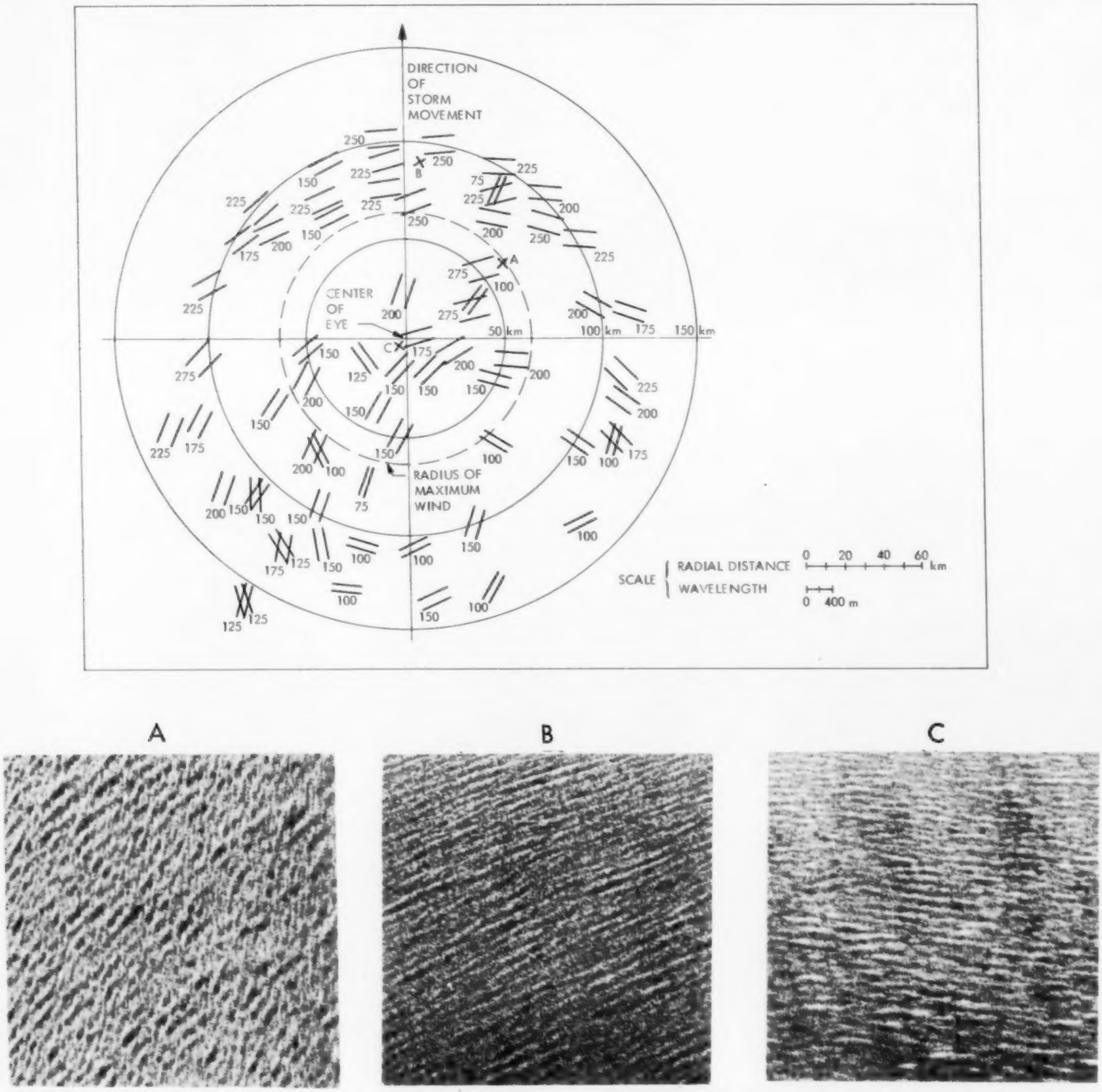

Figure 7.--Wave patterns generated by hurricane Gloria on September 30, 1976. The imagery was obtained with the Jet Propulsion Laboratory L-band synthetic aperture radar mounted on the NASA Ames CV-990 aircraft. The wave fronts are shown as two parallel lines. The separation between the lines is proportional to the wavelength, which is also marked in meters. The locations are all referenced to the center of the hurricane eye. The dashed circle corresponds to the region of maximum wind. The maximum low-altitude wind measured was 100 kn. The three images (A, B, C) are examples of the radar imagery taken at corresponding locations. The dimensions of each image are 7 km by 7 km. Courtesy of C. Elachi, Jet Propulsion Laboratory.

imaging microwave radiometers (19.3 and 37 GHz, respectively) with comparable spatial resolutions to SMMR. An analysis of the Arctic near minimum and maximum sea-ice boundaries is shown in figure 8 for the 1972-73 seasons from NIMBUS-5.

The near 20-km spatial resolution available from the passive microwave sensors on NIMBUS-5, 6, and G has an advantage over visible and infrared sensors by virtue of cloud penetration in the polar regions where water vapor is at a minimum. An additional benefit is the discrimination between first- and multi-year ice.

Other complementing sensors to SMMR are the 1-km visible and infrared data from the NOAA series and the advanced instruments to be operational on the TIROS-N system. LANDSAT-1, 2, and C provide

Figure 8.--Near minimum and maximum Arctic sea-ice boundaries for 1973 based on NIMBUS-5 Electronically-Scanned Microwave Radiometer. Courtesy of P. Gloersen, NASA Goddard Space Flight Center.

visible imagery at 100 m, but unfortunately the visible systems perform poorly at the low-light levels in the polar regions during winter when data is most needed.

While the SAR system requirements have primarily addressed the imaging of surface waves, the most straight-forward product to be generated by SAR will be sea-ice images from which the dynamic, lead, and polynya conditions can be observed. The coverage will not be large, nor available in real time. The ice images can be acquired under all weather and day or night conditions at about 25-m resolution. A segment of a typical sea-ice image is shown in figure 9. SAR images will be 100 km on a side rather than the 8 x 30 km segment shown here that was acquired by aircraft. Major ice floes can be observed, ice movement and development of lead systems monitored, environmental relationships between air, sea, and ice observed, formation and breakup of shore fast ice detected, and the refreezing of leads and polynyas observed. This will greatly benefit Arctic ice research, transportation, and facilities development.

This ensemble of satellite sensors to be available in 1978 offers an excellent opportunity to overcome the limitations in understanding the extent and morphology of sea and lake ice. Current limitations are primarily due to the harshness and remoteness of the location of the Earth's floating ice, a limitation not imposed on the satellite observing systems.

Other Applications and Experiments--As shown in tables 2 and 3, many applications are anticipated for SEASAT-A and NIMBUS-G. A Program Development Plan for SEASAT-A has been prepared by NOAA, and a similar plan is in preparation for NIMBUS-G. A joint Announcement of Opportunity for experiments will be released to the academic and industrial marine community for SEASAT-A experimentation. NOAA and NASA are taking the lead in this joint activity with support from the National Science Foundation, Office of Naval Research, the U.S. Coast Guard, and the U.S. Geological Survey.

SUMMARY

The SEASAT-A and NIMBUS-G research satellites will provide a focus for marine and space scientists to apply new methods to old problems. The optimism of the late 1960's in space technology of doing many things better, cheaper, and more quickly is giving way in the late 1970's to the reality that remote sensing still requires actual surface observations. And, similarly, if current environmental models are to be improved for better oceanic weather analyses and forecasts, the marine data base must be significantly extended. Thus, 1978 will provide a unique opportunity to improve current knowledge of sea-air interactions and the role that satellite systems play in providing marine data for analyses and forecasts.

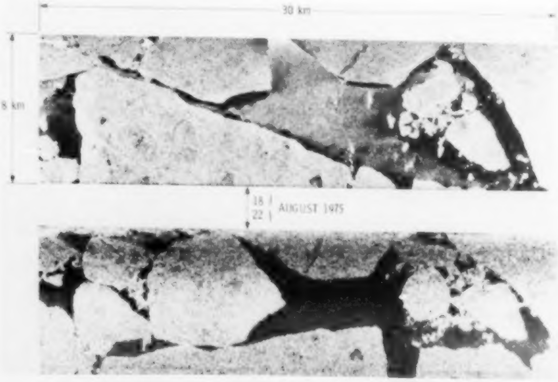

Figure 9.--Sea-ice imagery by the Jet Propulsion Laboratory airborne L-band synthetic aperture radar showing summer polar ice movement. Courtesy of C. Elachi, Jet Propulsion Laboratory.

HONG KONG AS A TYPHOON HAVEN

Mariners Weather Log

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Editor's Note: This is the second in a series of articles evaluating the safety of ports as shelters from tropical cyclones. These are edited versions of studies that appear in the Typhoon Havens Handbook for the Western Pacific and Indian Oceans by Samson Brand and Jack W. Blelloch, June 1976, Naval Environmental Prediction Research Facility, Monterey, Calif.

According to statistics, Hong Kong can expect to be seriously affected by one tropical storm in any given year and one typhoon every 10 yr. But averages can be misleading. Take 1971 for example. In June Freda brought 103-kn gusts to the colony as she crossed the China mainland between Hong Kong and Macao. In July Lucy, in her waning stages, generated 80-kn gusts as she passed 15 mi northeast of Hong Kong. Then, in August along came Rose with 120-kn gusts and a record 11.34 in of rain in 24 hr. Rose was one of the most devastating typhoons ever to hit the port of Hong Kong. Some 26 oceangoing vessels were pushed aground, 2 sank, and about 300 small craft were either sunk or damaged. The Macao ferry FATSHAN (fig. 10) capsized causing the loss of 88 lives--one of the colony's worst maritime disasters.

Hong Kong Harbor cannot be designated as a "safe" haven in time of severe winds and waves associated

Figure 10.--Capsized ferry FATSHAN in the center of the picture is surrounded by five freighters that ran aground on Lan Tau Island, Hong Kong, during typhoon Rose.

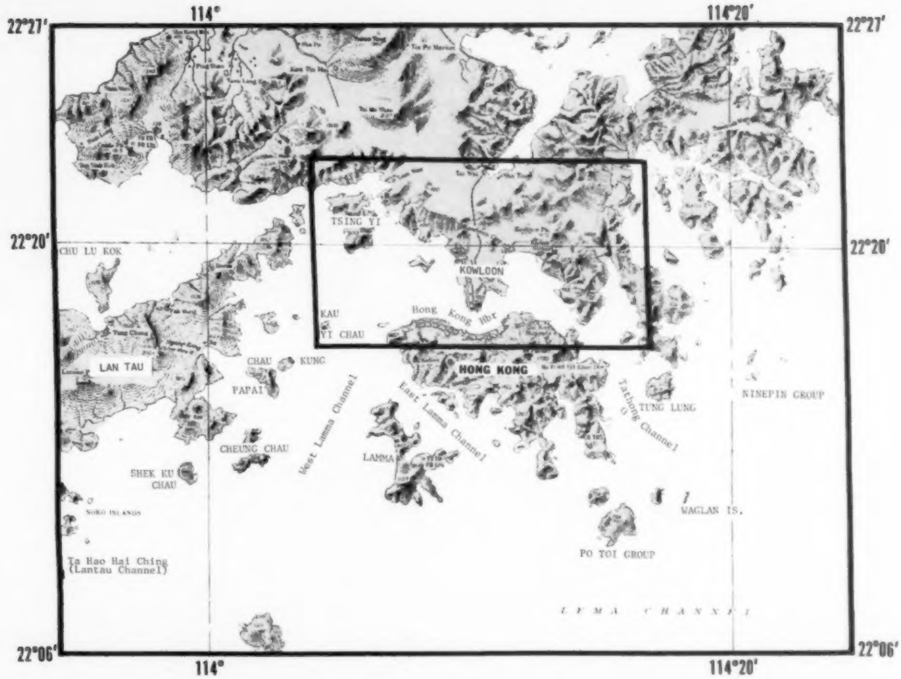

Figure 11.--The island of Hong Kong in relation to the China coast. The outlined area is enlarged in figure 12. Defense Mapping Agency Hydrographic Center, 1972.

Figure 12.--Hong Kong Harbor. Government Publication Center, 1971.

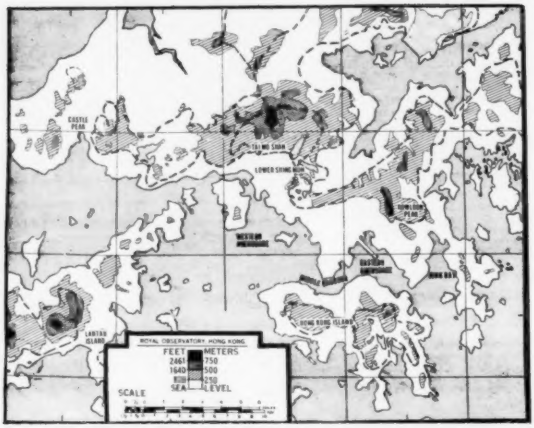

Figure 13.--Topography of Hong Kong and the surrounding area. From Morrice, 1973a.

with the passage of tropical cyclones. Small ships unable to outrun and evade at sea or ships unable to put to sea should be thoroughly familiar with the potential problems of remaining in port. It is recommended that all other ships take early decisive action to clear Hong Kong Harbor and evade at sea.

THE SETTING

The South China coast lies east-northeast to west-southwest from Taiwan Strait to the Luichow Peninsula (fig. 11). It forms a rugged and well-indented coastline with a multitude of small islands. In adverse weather it is a dangerous shoreline. Inland, major mountain ranges run approximately east-west.

The British crown colony of Hong Kong is the principal deepwater port for South China and one of the best deepwater anchorages in the world. The colony consists of a British-owned section--Hong Kong Island and the Kowloon Peninsula--and a leased section known as the New Territories. The overseas docks are situated on the Kowloon side (fig. 12). On the northern shore of Hong Kong Island is the city of Victoria, commonly known as Hong Kong. Extending over 5 mi along the harbor, it is a picturesque city as it stretches from the reclaimed shoreland up the hillsides of Victoria Peak (1,823 ft).

The main topographical features of Hong Kong are two ranges of hills (fig. 13). Over the New Territories in the north, a well-marked ridge runs east to west from Kowloon Peak to Tai Mo Shan and Castle Peak. About 8 mi south of this is another ridge, also oriented east-west, consisting of Hong Kong Island and Lan Tau Island, broken by a gap of about 6 mi.

Hong Kong Harbor (22.3°N, 114.2°E) lies between the north side of Hong Kong Island and the China mainland. It varies in width from 1 to 6 mi and covers an area of 23 sq mi. The harbor and anchorage areas vary in depth from 3 to 6 fathoms, with 1 to 6 fathoms at the berth. The tidal rise varies from 3.1 to 5.3 ft. Depths of approaches and entrances to the harbor are as follows (see figs. 11 and 12 for locations):

	Fathoms
East approach:	
Tathong Channel	6-1/2 to 10
East entrance:	
Lei U Mun Channel	13
West approach:	
West Lamma Channel	4-1/2 to 5
East Lamma Channel	4-1/2 to 10
West entrance:	
Sulphur Channel	4 to 14

THE CLIMATOLOGY

The tropical cyclone season for Hong Kong runs from July through October, although gales (windspeed $\geq$ 34 kn) associated with the passage of tropical cyclones have been recorded as early as May 19 and as late as November 23 (fig. 14). Tropical cyclones can and do occur at any time of year, but storms in the off season (November through May) seldom have affected the port of Hong Kong in the past.

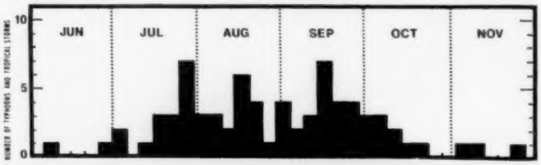

Figure 14.--Frequency distribution of typhoons or tropical storms resulting in gale-force conditions at Hong Kong for 5-day periods, based on 62 yr of data. Haywood, 1950.

Climatology indicates that five or six tropical cyclones threaten Hong Kong each year and require hoisting of the number one local storm warning signal,[1] with one of these storms coming near enough to cause gales. On the average, once in every 10 yr the center of a fully developed typhoon passes sufficiently close to the harbor to provide sustained typhoon-force winds ($\geq$ 64 kn) and cause severe damage to shipping in the harbor as well as local inland flooding. This does not, however, preclude the occurrence of such a storm during any particular year.

For the most part, the onset of gale-force winds occurs as tropical cyclones cross 115°E and is generally associated with storms approaching within 90 mi (fig. 15). Note that very few tropical cyclones passing north and east of Hong Kong give strong or gale-force winds to Hong Kong. Even though approximately 40 percent of the tropical cyclones passing within 180 mi of Hong Kong pass to the north, many of these storms weaken rapidly as they move inland and do not present a severe threat to the port.

If the center of a tropical cyclone passes to the south and crosses the South China coast to the west of Hong Kong, local winds will be generally from the east or southeast with gales possible for several hours,

[1]Definition of Storm Signal 1: A tropical cyclone is centered within about 400 mi of Hong Kong and may affect Hong Kong. Storm signals are given in figure 25.

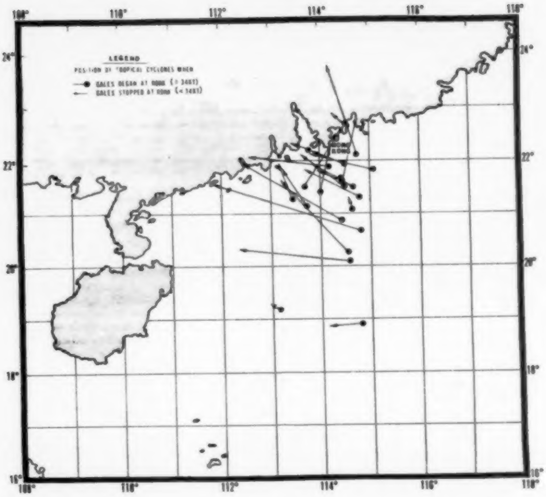

Figure 15.--Positions of tropical cyclone centers when the first and last gale-force winds ($\geq$ 34 kn) occurred at the Royal Observatory, Hong Kong, based on data from 1936-64. Royal Observatory Hong Kong, unpublished.

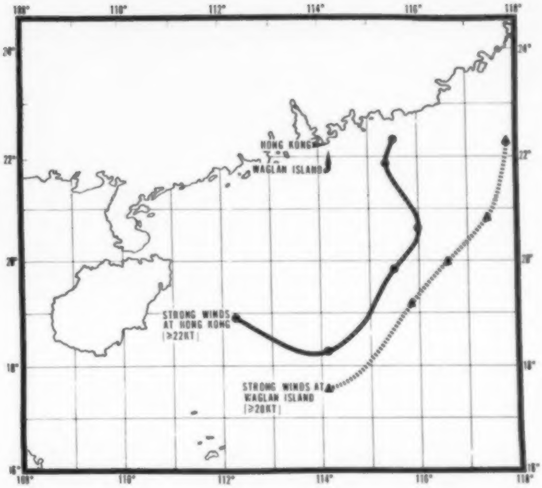

Figure 16.--Bearing and mean distance of tropical cyclone centers when the first strong winds were reported at the Royal Observatory (solid line) and at Waglan Island (dashed line).

providing Hong Kong comes under the direct wind circulation of the storm. If the center of a typhoon moves northward to the east of Hong Kong, winds will be from the north to northwest, and gales are less likely unless the storm is intense or passes relatively close to Hong Kong. In addition, rainfall can be expected to be quite heavy in the former case (a typhoon passing to the west of Hong Kong), compared to relatively lighter precipitation when a typhoon passes to the east of Hong Kong.

The general east-west orientation of the ranges of hills on both Hong Kong Island and Kowloon tends to channel, deflect, and even reduce or increase the winds from approaching storms. An example of this effect can be seen in a comparison of the onset of strong winds (fig. 16) at the Hong Kong Royal Obser-

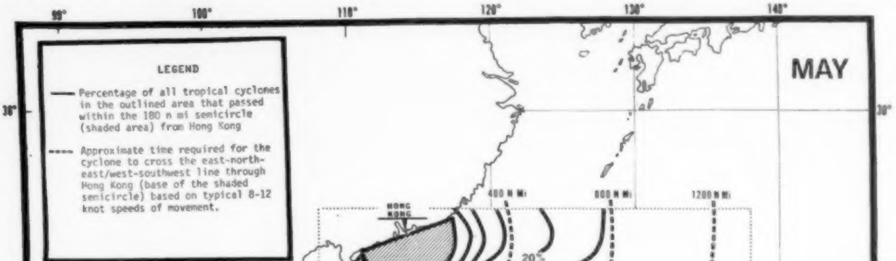

Figure 17.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in May, based on 87 yr of data.

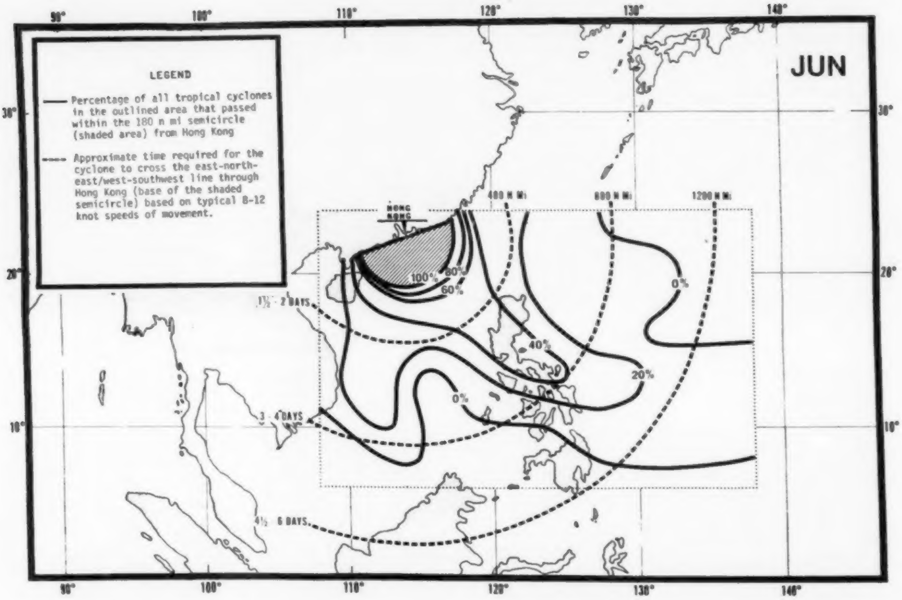

Figure 18.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in June, based on 87 yr of data.

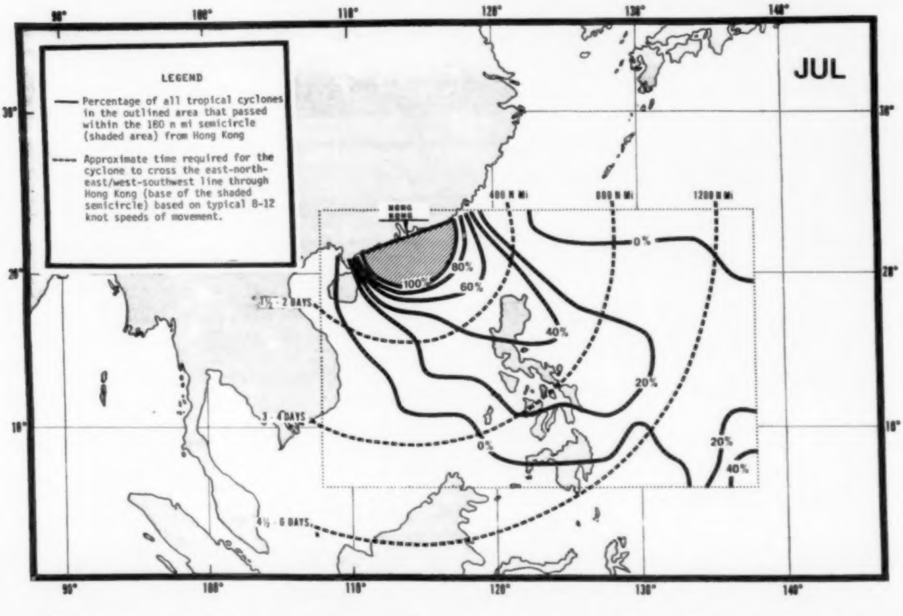

Figure 19.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in July, based on 87 yr of data.

vatory and the more exposed Waglan Island. Note the wind criteria were even less intense at Hong Kong. Strong winds begin at Waglan Island when the storms are at a much greater distance, or, in other words, they started blowing earlier than they did at Hong Kong. It can be seen also that strong winds at both Hong Kong and Waglan Island began sooner when the storms approached from or were located to the south, as compared to any other direction.

Figures 17 to 23 show the percentage of tropical

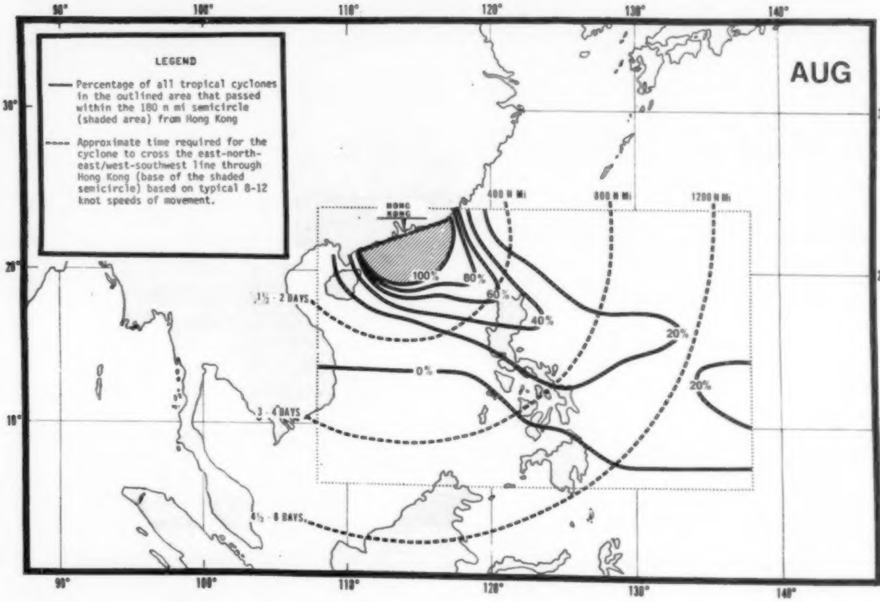

Figure 20.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in August, based on 87 yr of data.

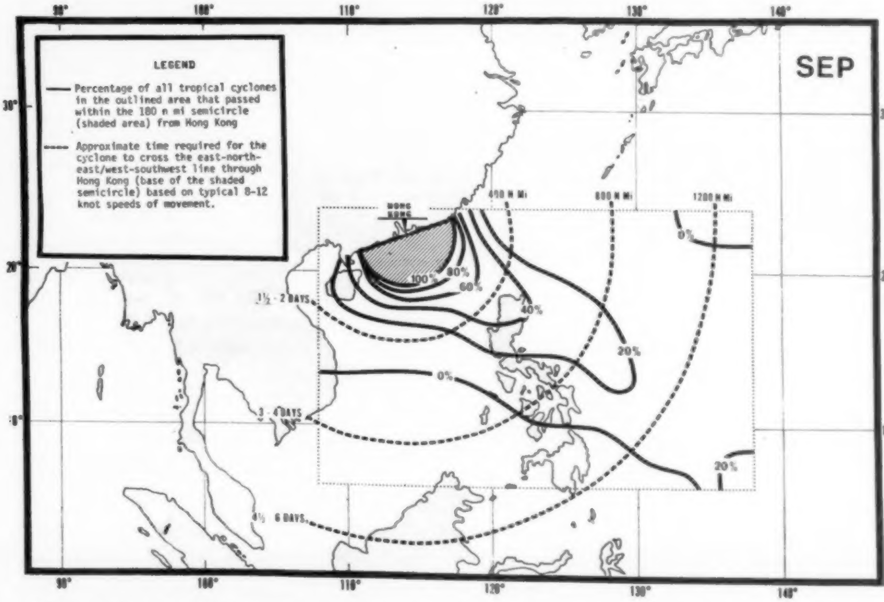

Figure 21.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in September, based on 87 yr of data.

cyclones which have passed within the 180-mi semicircle to the south-southeast of Hong Kong. This can be interpreted as the probability of "threat." In addition, the approximate time required for the cyclone to reach Hong Kong is shown, based on typical speeds of movement of from 8 to 12 kn (the faster the speed, the sooner the time of reaching Hong Kong).

For example, figure 17 shows that of all the tropical cyclones in May over the 87 yr of data that crossed over the Northern Luzon area of the Philippine Islands,

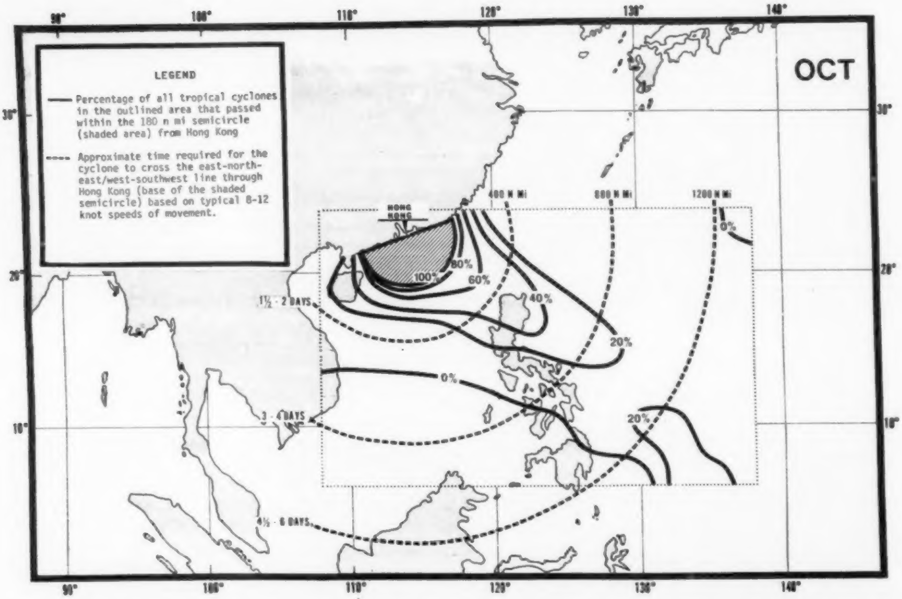

Figure 22.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in October, based on 87 yr of data.

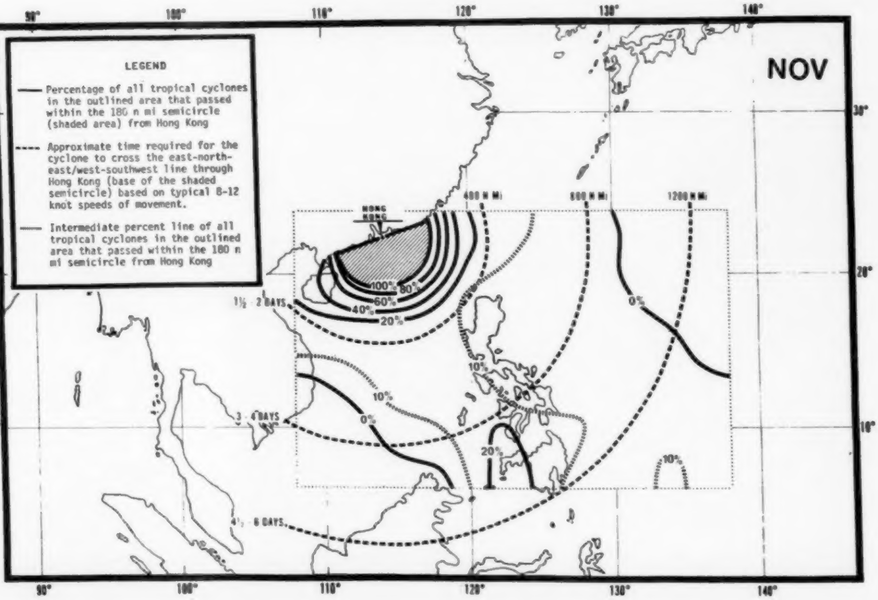

Figure 23.--Probability that a tropical cyclone will pass within 180 mi of Hong Kong (shaded area) in November, based on 87 yr of data.

approximately 10 percent entered the semicircle 180 mi from Hong Kong. Additionally, those tropical cyclones which reached Hong Kong did so within about 2-1/2 days.

THE PROBLEM

Any tropical cyclone passing within 25 mi to the east and 50 mi to the west of Hong Kong will have a serious effect on all areas of the harbor. Storm

surges and wave action can cause dangerous rises in sea level.

The natural harbor of Hong Kong, like any other harbor, is subject to "storm surge" effects as the tropical cyclone approaches landfall. Storm surges can be defined as the difference between the observed water level during the storm and that which would have occurred at the same time and place in the absence of the storm.

Tropical cyclones in the past have yielded storm surges in Hong Kong from 2 to 6 ft. Sea walls and piers have been known to be awash when the surge coincided with a high tide. Within the harbor, the sea becomes very confused with short, steep waves. Should the wind go south or southwest, dangerous conditions prevail in Western Anchorage. Obviously, the closer the center passes to Hong Kong, the greater is the effect on the harbor. Unfortunately, there is no particular area of the harbor which could be considered as favorably situated under such conditions. The danger of ships broken adrift and out of control can cause considerable damage in the tight quarter of the harbor.

A problem more peculiar to Hong Kong than many other ports in the western Pacific is the rapid building of seas at the entrance to the harbor. Adequate time must be allowed to clear the harbor in order to avoid these high seas and gain maneuvering room in the open ocean. Wave heights over 30 ft have been observed during typhoon conditions just outside Hong Kong Harbor, and wave heights of over 20 ft have been observed for intense tropical cyclones even hundreds of miles away.

The majority of tropical cyclones approach Hong Kong from the southeast (fig. 24). Resultant winds

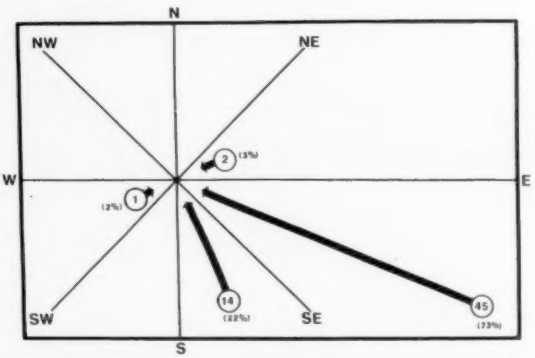

Figure 24.--Direction of approach to Hong Kong of tropical cyclones. The length of each line is proportional to the number of occasions on which typhoons and tropical storms approached from each octant of the compass. From Haywood, 1950.

are from the north. Because of the rugged terrain to the north, the local winds are less severe than might otherwise be expected, so that any tropical cyclone running inland over 50 mi east of Hong Kong is likely to have little effect on the harbor. However, as the circulation moves north and weakens, there is often an increase of wind strength from the southwest. This will affect Western Anchorage in particular, which has a long fetch towards the south and may therefore experience destructive seas.

As the bearing of a storm changes from south to south-southwest, the local winds will veer to the east. Because of the topography, there is a well-marked tendency for the winds to remain easterly in Middle Harbor and Western Anchorage even if the bearing of the tropical cyclone becomes southwesterly (provided the center is over about 150 mi from Hong Kong). In Junk Bay the wind will probably change suddenly to southeasterly and increase with a rapid buildup of wave height under these conditions. In such a situation all sections of the harbor will be exposed and dangerous.

When a tropical cyclone moves northward 50 to 150 mi to the west of Hong Kong, winds are unlikely to veer beyond southeasterly, and so Western Anchorage and Middle Harbor will be relatively sheltered, while Eastern Anchorage and Junk Bay would become more exposed. However, once the circulation has hit land, winds may become south or southwesterly, with a sudden increase in the Western Anchorage.

"Seiche" effects, or the natural period of oscillation between the harbor and incoming swell wave that can produce a rapid rise and fall of the water level, do not appear to be a significant problem in the open-ended harbor of Hong Kong. Additionally, since the harbor is open to both the east and west, it acts to dissipate, to some extent, the seiche and storm surge amplitude (Watts, 1959).

THE DECISION

The key to a safe evasion lies in an awareness that a threat to the harbor exists. Tropical cyclones which cross the northern portion of the Philippines into the South China Sea and finally strike the China coast, have, in the past, had a relatively high probability (37 to 56 percent throughout the June to October typhoon season) of passing within the 180 mi, overocean semicircle from Hong Kong. Sorties from Hong Kong must be made early in order to gain maneuvering room in the open ocean. Within 24 hr of a tropical cyclone crossing the Philippine Islands, swells can be generated that can severely hamper a ship's speed of advance although the storm may still be a great distance from Hong Kong. In the case of typhoon Rose, even with the center of the storm 100 mi south of Hong Kong, maximum seas in excess of 30 ft were observed by a wave recorder at Waglan Island (at the eastern approach to the harbor). These seas were measured approximately 14 hr before Rose struck the China coast just outside the harbor. Consequently, sortie action even 14 hr prior to the Closest Point of Approach (CPA) to Hong Kong of typhoon Rose, with 30-ft seas at the entrance to the harbor, would have been very hazardous to say the least. Decisive action must be taken early.

To help make an early decision, local warning bulletins and forecasts are issued regularly by the Royal Observatory Hong Kong (ROHK) whenever a local wind warning signal is hoisted. ROHK advisories are available to all ships in port at Hong Kong via the harbor net circuits. Information and bulletins are also broadcast at frequent intervals by domestic radio stations. As the tropical cyclone nears Hong Kong, local radar can yield an excellent fix of the center position if the cyclone is well defined. Storm signals

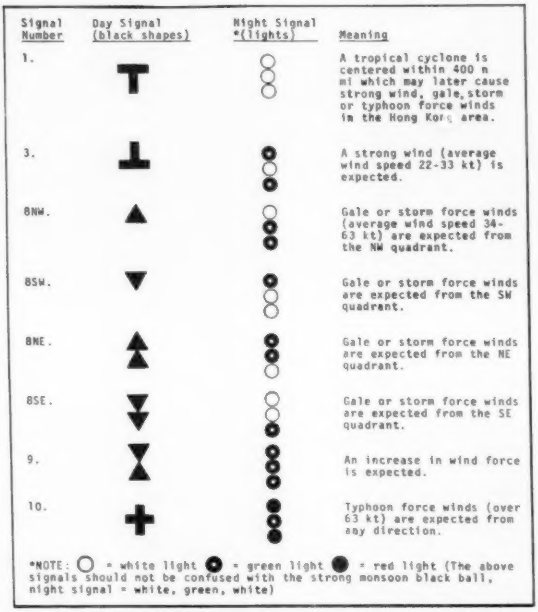

Figure 25.--Hong Kong storm signals.

displayed in the harbor are shown in figure 25.

The experience of the Royal Navy is useful in making an early decision (Morrice, 1973b). They do not consider Hong Kong a suitable haven under typhoon conditions. The normal naval policy is for warships of frigate displacement and above to put to sea in sufficient time for adequate evasion to be possible. Smaller units (patrol craft and coastal minehunters) normally secure to buoys in Victoria Harbor. It is a matter of policy that no naval ship remains alongside. The quay walls in the Naval Basin are considered too low because of the possibility of storm surge reinforcing high tides. Serious bumping with major damage and capsize resulting are considered very real consequences of staying alongside.

The Marine Department at Hong Kong offers the following advice. Junk Bay and the eastern approaches to Hong Kong Harbor are not considered to be suitable areas in which to anchor during typhoons, and there is no longer any space available in Kowloon Bay for use as a typhoon anchorage. The most popular anchorage during the passage of tropical cyclones is on or to the westward of Kellett Bank (latitude 22°18'N, longitude 114°06.5'E) where the depth of water varies from 3 to 12 fathoms.

When anchoring for an impending tropical cyclone, ample cable should be paid out at once without waiting until the force of the storm is felt as paying out then tends to disturb the anchor. Ships should always have their second anchor ready for letting go and use it before the winds reach gale force.

Masters of vessels who may be required to shift berth in the event of a tropical cyclone affecting the Colony, should bear in mind that the services of tugs are at a premium immediately before and following the passing of a tropical cyclone. Tugs are then generally employed in shifting vessels to and from dockyards. Calls for towage assistance should therefore be kept to a minimum and made only in case of real emergency when life and ships are endangered.

Despite the quality of the bottom, anchoring in either eastern or western anchorages is considered undesirable. In every major typhoon since the war a considerable number of ships have broken adrift from moorings and anchorages; these drifting hulks then present a deadly threat to ships in their path. The tragic loss of life on the FATSHAN in typhoon Rose was attributed to some extent to collisions with ships which had broken adrift and were not under command.

The overall policy is to "retain flexibility." This often entails decisions at an early stage when the magnitude of the threat is unknown and difficult to predict. However, adequate planning at this time can prevent the disastrous consequence of being unable to react in the way one would have wished at a later stage. It is considered essential to take precautions and be prepared early, and then stand down should the threat diminish. The following is offered as rough guidelines which could be used during a normal sequence of events with a slow buildup (fig. 26). The times given are for an 8- to 12-kn movement.

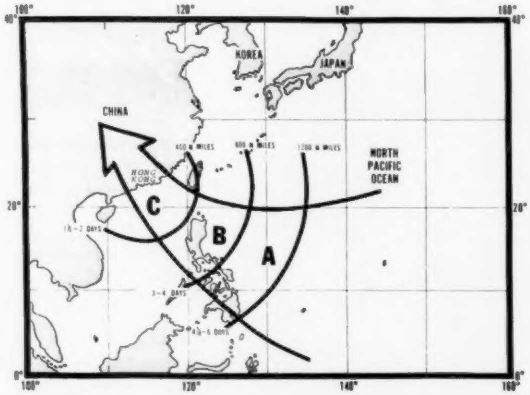

Figure 26.--Areas of concern for Hong Kong from tropical cyclones. From Morrice, 1973b.

1. A tropical cyclone in Area A (fig. 26) (or even a potential development in Area A) with a meteorological situation which indicates a possible movement towards Hong Kong:

a. Review the material state of the ship. Evasive action may be desirable in 2 to 4 days.

b. Ships under maintenance should be considered more carefully. Any at 48-hr notice will require a decision, even at this early stage, if flexibility of action is not be be lost later.

2. If a tropical cyclone moves into Area B and the meteorological situation indicates a threat to Hong Kong:

a. Fully operational ships should start planning

what course of action they will take should sailing be necessary.

b. Ships under maintenance at 24-hr notice require a decision at this stage.

3. A tropical cyclone enters Area C:

a. All plans made during the previous states now go into effect.

b. Ships intending to sail should proceed.

c. The smaller ships should secure to their typhoon buoys before local winds reach 20 kn. Experience has shown that considerable difficulty can be encountered in securing with wind above this speed.

THE EVASION

The decision to sail, once taken, poses the new problem of the best course once at sea. This section is based on the experience of the past few years. However, the captain with his detailed knowledge of the ship and crew, must always make his own personal decision as the situation dictates.

1. A tropical cyclone approaching from the south toward Hong Kong:

This is undoubtedly the greatest threat to the harbor and unfortunately the most difficult to evade. There is little choice but to run an initial course of 090° True in order to obtain sea room in which to maneuver. This course is only acceptable, however, if recurvature and acceleration of the storm towards the northeast are unlikely. Otherwise, a ship could be easily trapped in the path of the storm.

2. A tropical cyclone approaching from the southeast after crossing Luzon, Philippines, occurs most often and requires two major criteria for evasion:

a. Early sailing on a southwesterly track in order to cross well ahead of the tropical cyclone into the safe semicircle.

b. A ship which rides fairly well in a following sea.

Crossing ahead of a typhoon is a serious matter not to be treated lightly. However, Somervell and Jarrell (1970) indicated that one of the most successful tactics in the Pacific involves crossing of the "T", that is, running downwind and downsea ahead of the typhoon in order to cross the track and reach a position south of the storm. It is emphasized that "crossing of the track" must be done well in advance. If not, the speed of advance of the ship may be hampered due to severe seas and swells, and the ship will be hopelessly trapped in the direct path of the oncoming typhoon. This tactic should not be attempted unless it can be managed outside the area covered by the expected radius of 30-kn winds.

3. A tropical cyclone approaching from the southwest after recurvature or development over the South China Sea:

Early departure on a southeasterly track is the key in order to avoid as much as possible the headon winds and seas that will significantly reduce any intended speed of advance. However, according to climatology, a tropical cyclone approaching from the southwest is unlikely.

The following should be considered if the decision is made to remain in the harbor, which would apply to smaller ships unable to outrun and evade at sea or those ships unable to put to sea:

1. The possibility exists, at the discretion of the captain-in-charge, of having to vacate the typhoon buoys on short notice for a less desirable spot in Western Anchorage.

2. Securing to buoys should be done before winds reach greater than 20 kn locally in order to prevent undue difficulty in securing. Note that tropical cyclones bearing 180° (170° - 190°) from Hong Kong (due south) have on the average produced winds in the harbor greater than or equal to 22 kn at a mean distance of 242 mi.

3. The holding action of the bottom in the anchorages, although good, cannot be expected to prevent dragging in winds of typhoon intensity. In the case of typhoon Rose, the REGULUS experienced extreme anchor drag prior to grounding, even though steaming to the anchor.

4. Storm-surge effects as a result of a typhoon moving inland may result in the increase of the mean water level up to 6 ft above normal with storm surge coinciding with high tide and a strong southeasterly wind.

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GREAT LAKES ICE SEASON, 1976-77

Mariners Weather Log

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The worst ice conditions of the past 30 yr were reported on the Great Lakes during the winter of 1976-77. Commerce continued through the season, but the iron ore trade from Lake Superior into southern Lake Michigan and Lake Erie was suspended for almost 2 mo during midwinter--the first such break in traffic in 3 yr. Direct icebreaking assists by the U.S. Coast Guard were up nearly 55 percent over the previous season.

FALL SEASON

With the addition of another 1,000-ft vessel in the iron ore trade, tonnages were over 2 million above the previous year's total by midfall. By the end of the year demands were much lower, and the natural ore season ended in Duluth on October 24. Some ships were layed up shortly afterward. Other ore ships shifted over to grain handling for the month of November.

The generally frigid autumn produced very rapid cooling of Great Lakes waters. Air temperatures were from 5° to 7° below normal for November and from 7° to 9° below normal for December, with the exception of Lake Ontario where readings averaged only 4.7° below normal. Some early season ice was reported in navigation channels in northern lake ports

Figure 27.--The JOHN E. KLING followed by another ship in the background passes a third headed in the opposite direction in icy Lake Erie waters.

Figure 28.--The Yugoslavian RUDER BOSKOVIC races for the sea to clear the Lakes before ice closed the waterways.

by mid-November. Duluth Harbor, southern Green Bay, Little and Big Bays De Noc, and a number of the northern bays in Lake Superior were all ice covered by December 1. On the 2d the river water temperature at Sault Ste. Marie reached freezing--the earliest date on record. The air temperature had dropped to -24°F, the coldest for any date since February 2, 1971. Within a few days, ice had spread into Saginaw Bay, Lake St. Clair, and western Lake Erie (fig. 27). The Coast Guard reported that ice damage to their floating navigation aids was the worst in 30 yr. In early November the National Weather Service predicted the heaviest ice year since extended navigation began in 1971. Ice was forecast to form much earlier and become unusually thick because of the rapid fall cooling and severe winter ahead.

Only days later the Lakes began to take their toll. The Norwegian ship KINGS STAR drifted helplessly in Lake Erie on December 1. Numerous vessels were pushed out of their dredged channels by ice, and by year's end 20 ships had gone aground. The worst incident was the grounding of the CLIFFS VICTORY. She went hard aground near Johnson Point in the lower St. Marys River on December 9, blocking the two-way channel. While part of her cargo was off-loaded and tugs pulled her free, a record 71 ships went to anchor. At least one of the delayed ships was a foreign flag racing to pick up a cargo in Duluth for Europe before the closing of the St. Lawrence Seaway System on December 18. The downbound West Neebish Channel had been closed because of ice at midnight on December 8.

The U. S. Coast Guard cutter BRAMBLE provided the first direct icebreaking assist of the season when she aided the E. M. FORD and the NICOLET in Saginaw Bay on December 3. The next day the Canadian MEAFORD was helped in the St. Marys River by the NAUGATUCK. Several vessels were assisted in Green Bay by the ARUNDEL. The polar icebreaker WESTWIND was ordered from her homeport in Milwaukee to Duluth and the MACKINAW from Cheboygan to Saginaw Bay on December 6. They chalked up several assists by midmonth. The unrelenting cold continued, new ice formed in the Straits of Mackinac, and drift ice appeared in the Detroit and St. Clair Rivers.

Exceptionally severe ice conditions on the St. Lawrence Seaway System delayed the closing several days in order to get the last few foreign ships to Atlantic waters (fig. 28). Water temperatures on December 8 were the lowest for that date since the Seaway opened in 1959. Shipping was halted from December 12 to 14 to permit a stable ice cover to form, thus reducing the likelihood of damage to hydroelectric facilities. The Liberian freighter ATTICA and the Canadian SEA-

Figure 29.--Ice rides up on the bow of the MEDUSA CHALLENGER as she moves through brash ice on one of her last trips of the season.

WAY QUEEN were the last ships to lock through on December 19. Similar problems plagued the Welland Canal. The Canadian BLACK BAY was the last ship to travel through on January 3, 1977. The TARANTAU started a voyage, but became stuck near lock 7 and had to remain there for the winter.

The colder late December temperatures continued to expand the ice cover with the major increases appearing in the Straits of Mackinac, southern Lake Michigan, southern Lake Huron, and central and eastern Lake Erie (fig. 29). The Coast Guard logged 238 icebreaking assists by New Year's Eve. A number of preventative icebreaking missions were also performed by Coast Guard vessels not deployed to remove seasonal aids to navigation. Traffic ended on Lake Erie by the end of December except for the "coal shovel" run between Toledo and Detroit. Traffic was discouraged by a reported 4 to 5 ft of ice in Pelee Passage. At the other end of the lake a record 54 in of snow at Buffalo rapidly cooled waters and formed a large ice cover. The task of installing the Niagara River ice boom near Buffalo was commenced on December 7.

Ice damage to commercial ships during fall 1976 was unusually high. Six incidents involving five ships were reported to the Coast Guard during December. Total damages were estimated at $33,000.

January 1977 was ushered in on a frigid note. Record-breaking cold chilled most of the Lakes region on the last day of December. In Cleveland the temperature dropped to -11°F. On New Year's Day, the PHILIP CLARKE sustained $24,000 damage while transiting Whitefish Bay in heavy ice.

Ice growth continued throughout the month with little letup in the severe cold. Temperatures on Lake Erie were over 13° below normal for the month--an unprecedented departure. The Canadian Coast Guard cutter GRIFFON tried to escort the CANADIAN MARINER across Lake Erie, but was turned back near Long Point. Ice jamming was reported in the St. Clair River, and the eastern two-thirds of Lake Erie froze over completely. By the middle of the month even the deepwater areas of the Upper Lakes were covered with ice, and 150 ships had been assisted (fig. 30).

Figure 30.--The USCGC WOODRUSH opens up a brash ice filled channel during January.

On January 11, there was concern that a major oil spill might be in the making when the AMOCO INDIANA ran aground in ice on the north side of Grand Traverse Bay near Lighthouse Point. The WESTWIND responded to her call for assistance, and by the 13th she was freed. Only 3 gal of her products were lost due to a closely monitored effort by the Coast Guard and her owners.

A major outbreak of Arctic air poured over the Lakes from Canada at midmonth with temperatures falling to new records. On January 16 it was -19°F in Chicago--2° below the old mark established in 1888. Very little snow melt occurred during the month because of the extended cold. Both Buffalo and Sault Ste. Marie indicated 2 ft of snow on the ground on the 16th. The coldest weather of the month, the year, and in many cases for several decades was observed the following morning. Duluth, Minn., reported -18°F; Toledo, Ohio, -15°F; and Cleveland, Ohio, -17°F. Vessel traffic ended on the 17th in Green Bay.

On January 19 the Corps of Engineers in Chicago announced that industry had informed them that the worsening ice conditions and almost continuous icebreaking assistance in Lake Superior and the St.

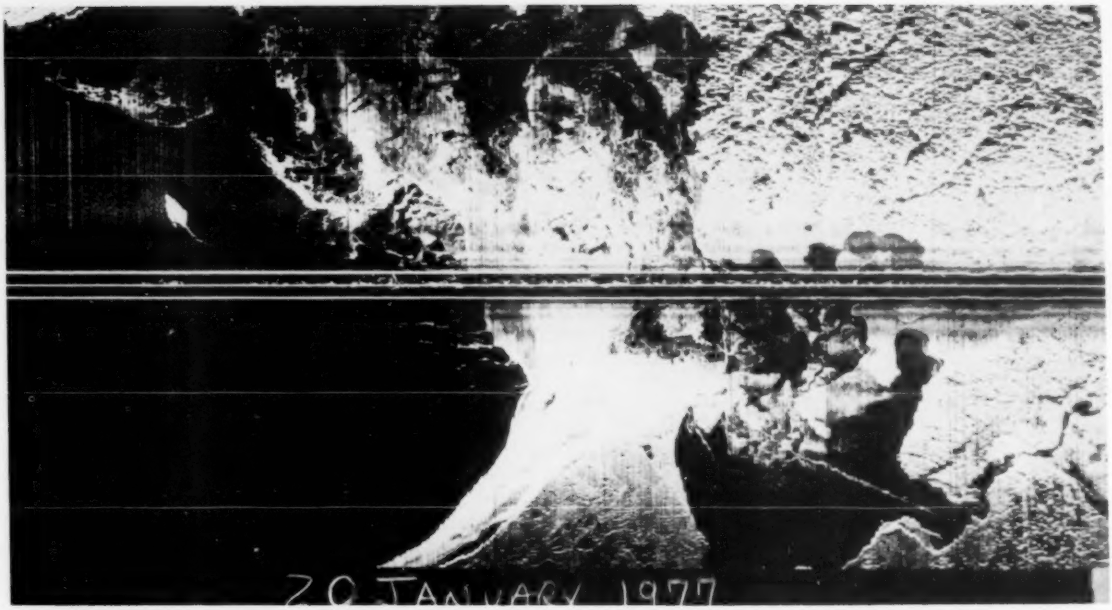


Figure 31.--An airborne SLAR image of ice on eastern Lake Superior and Whitefish Bay on January 20, 1977. The white trackline through the center of the Bay results from the high reflectivity of small pieces of brash ice.

Figure 32.--Coast Guardsman William Gilbert places a marker on Whitefish Bay on a wall-size chart to keep track of shipping during the ice season.

Marys River had prompted them to temporarily suspend navigation (figs. 31 and 32). The winter energy shortage was also emerging at that time, and unusual demands for Coast Guard assistance were being made for tankers. Rapid ice formation continued, and by the end of the third week nearly 70 percent of Lake Superior was covered. Increasing ice pressure in Soo Harbor broke two moorings of the Little Rapids Cut ice boom. Some vessel delays resulted, but the Sugar Island Ferry continued to operate. The boom was repaired on January 23, and the last ore vessels moved through the locks at Sault Ste. Marie on the 26th under escort of the MACKINAW. This was the first break in continuous navigation on western Lake Superior in 34 mo.

Perhaps the biggest weather story of the severe winter began unfolding in late January and continued to highlight the news well into February. Snow began to fall over eastern Lake Erie and western New York State on January 26. The snow continued into the 28th. At that point a severe blizzard developed in lower Michigan and swept across all of Lake Erie with winds gusting to 70 mi/h, a great density of snow, and temperatures hovering at about -10°F. The storm was most severe in Buffalo, where it virtually isolated the city for almost a week. Eighteen deaths were attributed to the storm in the Buffalo area. Ice thickened considerably on Lake Erie during this storm period. In early February thicknesses were reported up to 3 ft.

February was the landmark month on the Great Lakes. For the first time since 1963 virtually all of the Lakes with the exception of Lake Ontario were ice covered (fig. 33). The few remaining ships plying the Lakes required nearly constant icebreaking assistance. One of the Coast Guard's two major icebreakers, the MACKINAW, was damaged on February 3 while working in the St. Marys River. Her port shaft was bent, and one blade was sheared from her prop. Damages amounted to over $147,000.

The severe cold weather of January, which caused a halt in iron ore trade, actually created additional commerce in some areas. Several Canadian ships were engaged in the movement of critical fuels and supplies to Thunder Bay, Ontario, and several U.S. ports in early February. The DOAN TRANSPORT,

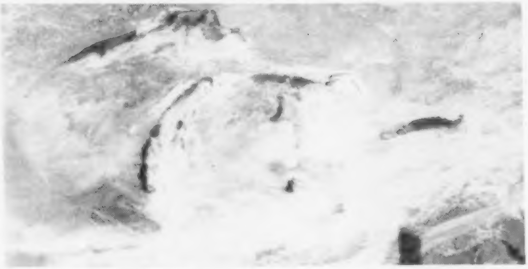


Figure 33.--On February 15, all the lakes are nearly completely ice covered with the exception of Lake Ontario.

HUDSON TRANSPORT, and IMPERIAL ST. CLAIR were the main Canadian carriers. The Amoco fleet and Hannah Inland Waterways managed deliveries in U.S. waters. Transits in 3 to 4 ft of ice were very slow. Trips between Sarnia and Thunder Bay, Ontario, took about 2 weeks.

Milder temperatures finally arrived during the second week of February, combined with westerly winds which dissipated some of the thin ice cover in midlake areas. Quite a bit of open water appeared in western Lake Superior, southwestern Lake Michigan, and the western half of Lake Huron. Duluth, Minn., had a record high for February 11 with 45°F. The next day a high of 42°F at Alpena also set a new record. An unusual weather record was noted in Buffalo on February 12--it was the first day since December 20 that snow did not fall on the city. The National Weather Service officially measured 176 in of snow up tc that point in the season.

In spite of the milder weather, ice continued to be a major problem for the Lake Michigan car ferries. The ice-strengthened vessels traditionally continue operations in the winter, but this year's ice brought them to a halt. The car ferry VIKING became beset off Frankfort on February 11. The tug JOHN SELVICK came to her assistance but was holed by the ice and lost her screw. Another tug, the LAUREN CASTLE, was dispatched but also became beset. Finally, the Coast Guard tug RARITAN arrived and assisted all three ships. A few days later the car ferry CITY OF MIDLAND lost one of her prop blades just outside of Ludington Harbor. Damages were reported to be over $200,000 (fig. 34).

On Lake Erie, the milder weather loosened much of the ice on northern Ohio rivers which flow into the lake. The Coast Guard dispatched the tugs KAW and ARUNDEL to break up the nearshore lake ice near the rivers, but the heavy brash ice was too much for them. The KAW damaged her rudder, and the ARUNDEL fractured her rudder post and prop. Damages totaled $72,000. The buoy tender BRAMBLE was the next to work on the ice fields. She was halted for awhile with a broken fuel line. She was joined by the polar icebreaker WESTWIND.

Colder weather during the third week of February resulted in considerable refreezing of previously opened areas. By February 21 Lakes Superior, Michigan, and Huron had become nearly ice covered again. Some of the thinner ice melted again by the end of the month. The Coast Guard logged just under 100 direct icebreaking assists during the month.

Figure 34.--A LANDSAT image of Lake Michigan on February 16. The lake is frozen over, which resulted in heavy damage to ships that attempted to operate.

SPRING OPENING

Much warmer temperatures were observed across the Lakes in March. The month began with a major snowstorm in the Upper Lakes. Duluth was covered with 8 in of snow on the 3d and 4th. Milder weather widened several areas of open water in northern and western Lake Superior, southwestern Lake Michigan, and western Lake Huron. Deterioration of ice cover was evident in nearly all areas, although the decrease of coverage was very gradual in areas of medium or thick ice. An open area in west-central Lake Erie slowly expanded eastward during the first half of the month. Soo Harbor and Little Rapids Cut on the St. Marys River became mostly ice free. On March 11 the temperature at Buffalo soared to 68°F, breaking

Figure 35.--This GOES image on March 10 shows the rapid deterioration of ice with warmer weather.

Figure 36.--A month later on April 9 virtually all the ice has melted. A critical area near Buffalo remains. Compare with figures 33 and 35.

the old mark of 66°F in 1927.

The eased ice conditions were encouraging enough for iron ore shippers to schedule a resumption of traffic to western Lake Superior ports (fig. 35). On March 15 U.S. Steel's ANDERSON, CALLAWAY, CLARKE, and MUNSON left Milwaukee for Two Harbors. The CALLAWAY was the first to transit the American Soo Locks on March 18. The date was considered to be the earliest on record for the opening of the "spring" season. On the Lower Lakes, the season was opened with the arrival of 6,000 tons of cement on the S. T. CRAPO. Most shipping companies delayed their first fitouts until later in April. Thirty commercial ships were operating by the end of March.

The latter half of March was marked by continued deterioration of remaining ice cover in all areas. By monthend the greatest concentration of ice cover on Lake Superior was in eastern areas. Whitefish Bay and lower St. Marys River remained ice covered. Lake Michigan ice became confined primarily to the northern quarter of the lake from Green Bay through the Straits. Ice in Lake Huron continued to diminish gradually. The mild temperatures and strong southwest winds combined to push the ice out of Saginaw Bay. The temperature reached a high of 73°F in Alpena on March 30, breaking the old daily record by 5°.

The unusually thick ice cover on the St. Lawrence Seaway delayed the planned opening date to April 13. However, the milder March weather allowed passages about 10 days sooner. The Norwegian vessel THORSHOPE was the first upbound ship and the Canadian laker LAWRENCECLIFFE HALL took the honors for the first downbound on April 4. The same day two Canadian ships, the MANITOULIN and the QUETICO, were the first to transit the Welland Canal for the season. The Japanese freighter HAMAMASU was the first foreign flag vessel on the waterway on April 11.

Old man winter continued to leave reminders in early April. A major storm lashed the Upper Lakes again on April 5. Seventeen inches of snow fell on the Whitefish Point area of eastern Lake Superior. The Soo measured a fall of a little more than 7 in during the same 18-hr period. This was about 1 in shy of the all-time record 24-hr fall for April.

Milder weather was widespread during the second week (fig. 36). Continued steady decay and gradual diminishing of ice cover was the rule during the first half of April. Most of the ice had gone from western Lake Superior (aside from bays and around the islands) by midmonth. Whitefish Bay remained mostly ice covered. The upper St. Marys River opened. Lake Michigan ice cover continued to diminish in the Straits of Mackinac, Grand Traverse Bay, and Green Bay. Lake Huron ice was reduced to the Bruce Peninsula area, and the ice cover on Lake Erie virtually disappeared, except in the traditional windrowed area 15 to 20 mi west of Buffalo. Navigation was severely hampered in that area by the very slow melting. The USCGC OJIBWA enroute to this tough ice area on April 6 sustained steering damage and then became beset 11 mi west of Buffalo.

During the last half of April the remaining ice cover deteriorated rapidly. A narrow band of ice remained in the approaches to Duluth, but navigation was not seriously hampered. Only a few northern bays held ice elsewhere on the Upper Lakes. Coast Guard icebreaking operations "Taconite" on Lake Superior and the Straits of Mackinac and "Oil Can" on Lake Michigan were terminated on April 25. The ice boom on the St. Marys River was removed 3 days later. Sixty-three icebreaking assists were logged during the month--an increase mainly due to increased shipping activity which included low-power vessels.

Ice was especially thick in the Black Rock Canal in the Buffalo area in early May. The last icebreaking assist to shipping by the Coast Guard was made by the KAW to the tug TURECAMO and her barge. The Ice Navigation Center ended operations for the season on May 6, and the "Open Buffalo" operation ended on May 12 as the last few pieces of ice finally melted.

SUMMARY

The 1976-77 ice season was the most severe since extended winter navigation began during the winter of 1971-72 and was probably one of the most severe in the last century. The fall and winter months were consistently very cold throughout the Lakes region

Table 4.--Departures from normal of Great Lakes air temperature (°F) for 1976-77 season

Month	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario	Overall
November	-5.7	- 6.9	-5.6	- 7.0	-5.1	- 6.1
December	-9.7	- 9.2	-7.7	- 7.0	-4.7	- 7.7
January	-8.3	-11.0	-9.7	-13.7	-8.5	-10.2
February	+1.5	+ 0.2	-0.2	- 1.8	+0.6	+ 0.1
March	+6.5	+ 7.4	+8.0	+ 6.7	+6.8	+ 7.1
April	+3.7	+ 4.5	+4.0	+ 3.4	+1.8	+ 3.5
November-April	-2.0	- 2.5	-1.9	- 3.23	-1.5	- 2.2

Table 5.--Maximum accumulated freezing degree days (FFD)+ for 1976-77 season

Station	Maximum accumulated FDD 1976-77	Date	Normal maximum accumulated FDD	Date*	1976-77 season versus normal
Duluth	2616	March 7	2281	April 3	+335 (Colder)
Marquette	1680	March 6	1361	March 29	+319 (Colder)
Sault Ste. Marie	2243	April 9	1702	April 3	+541 (Colder)
Green Bay	2082	March 2	1416	March 26	+666 (Colder)
Milwaukee	1534	March 2	880	March 15	+654 (Colder)
Muskegon	1211	March 2	593	March 16	+618 (Colder)
Alpena	1628	March 3	1164	March 28	+464 (Colder)
Detroit	1129	February 21	**		+629 (Colder)
Toledo	1317	February 21	500	March 2	+817 (Colder)
Cleveland	1135	February 21	343	February 28	+792 (Colder)
Buffalo	1069	February 23	489	March 18	+580 (Colder)
Rochester	949	February 23	586	March 18	+363 (Colder)

+ A freezing degree day figure is obtained for each site by subtracting the mean temperature for the day from 32°F. Cumulative totals are compiled with negative daily figures (melting degree days) included.
* Historical date when normal maximum FFD occurs.
**Information not available--use Toledo data.

Table 6.--Summary of icebreaking assistance

	Operation hours in direct assistance	Mission miles	Total tonnage (GRT) of vessels assisted	Total cargo tonnage carried by vessels assisted*	Total value of cargo carried by vessels assisted*
FY 1971	4,080	14,101	3,453,708	2,520,152	$53,965,269
FY 1972	2,446.5	11,765.5	3,617,431	2,276,384	$61,862,404
FY 1973	1,341.6	9,494.2	2,076,701	1,470,995	$27,977,811
FY 1974	3,872.4	12,807.1	3,115,605	1,681,127	$45,640,302
FY 1975	2,575.2	11,275.4	5,788,909	3,662,653	$10,933,614**
FY 1976	2,775	11,586	4,553,832	2,937,083	$97,465,465
FY 1977	5,942.3	23,130.8	6,284,304	4,556,724	$125,142,602

* Types of cargo carried: cement, coal, grain, iron ore, limestone, petroleum products, pellets, soy beans, steel, taconite, wood pulp, and general.
**This figure is not representative of the true value of cargo carried due to the lack of reported values.

(table 4). Temperatures for the Lakes as a whole were over 10°F below normal--a departure unprecedented in National Weather Service records. The cold trend began to reverse in late February, and March and April were almost as unusually warm as the winter months had been cold.

As a result of the severe cold and massive ice coverage, winter navigation was suspended on western Lake Superior for the first time in 3 yr. Several trips by vessels transporting "energy" technically kept the Sault Ste. Marie Locks open, but no regular traffic moved through the St. Marys River or on Lake Superior from January 26 to March 18.

Freezing-degree-day accumulations are a measure of the severity of the winter season. The maximum totals this year were well above normal and in some cases were more than double the usual number (table 5). The maximum total occurred somewhat earlier than normal because of the warming trend that started in late February and continued through spring. Totals in the Lower Lakes peaked out about 3 weeks ahead of normal schedule.

The large extent of the ice cover this season resulted in a large increase in Coast Guard icebreaking assistance (table 6). Mission miles and operations hours were more than double last year's and the highest since the formal extended season program began in 1971. Records were also established for the amount and value of cargo carried by vessels operating during the winter. In all aspects it was a landmark year for ice and winter navigation on the Great Lakes--a year that will not soon be forgotten!

ACKNOWLEDGMENTS

Icebreaking data and casualty information was supplied by the Ninth Coast Guard District, Cleveland, Ohio. Additional information was obtained from the Northwest Ohio Great Lakes Research Center and the Great Lakes Commission Newsletter.

Hints to the Observer

OBSERVATIONS AND NOAA FORM 72-1

The following was excerpted from a letter from 2nd Officer W. McN Carslaw of the motor vessel BARRANCA to Robert W. Schoner, NWS Marine Observation Program.

"Recently, through various circumstances I have become an observer again. After a few years of non-participation, I find some difficulties cropping up, and no doubt, you are asked about some of these queries from time to time.

"I think I may be correct in saying the particular points I outline puzzle quite a few observers, and I suspect that incorrect figures may be entered because of lack of understanding.

"I find judging the sea and swell data difficult, and for wave period at night there seems to be no way other than making a guess at it. The remarks in the Observers Handbook are most useful, and it is interesting to know the swell is not reported when the sea and swell are within 30 degrees. I find it strange that the swell group is omitted when the sea is calm. Am I correct in saying that it is possible to have a calm sea but a swell running.

"Quite often at night clouds cannot be distinguished because of darkness, but the observation form is faithfully completed with various clouds no matter...

"I notice remarks about vapour trails and clouds of "C" described, but I fail to understand. Is this a misprint?

"Finally, past weather. I find this awkward to code. Generally speaking, it is only a rough guess from the ship's log book.

"Perhaps you can comment on these points, and I am sure any remarks you make will be of great assistance."

Yours faithfully,

W. McN Carslaw, 2nd Officer

Mr. Schoner's reply (below) should be of interest to all cooperating observers. For more information on sea and swell, see Hints to the Observer in the September 1977 issue of Mariners Weather Log.

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Md. 20910

August 23, 1977 W521x2/PB

W. McN Carslaw
2nd Officer
M.V. BARRANCA
c/o United Brands Co.
P.O. Box 1017
Gulfport, MS 39501

Dear Mr. Carslaw:

In regard to your questions, what can I say. You're right. Judging sea and swell is extremely difficult even for an experienced observer. Type, size, configuration, and speed of the ship, time of day (sun angle), direction of view in relation to wave train, height of observer above sea-level, all affect the accuracy of sea observations. Trying to write observing instructions to cover all the different possibilities is an impossible task. We rely heavily on our observers making wave observations and comparisons when conditions are good and making a "best guess" based on their experience and "feel" when conditions are bad.

Relative to your comments on the possibility of having a swell running but having a calm sea, the Weather Service Observing Handbook No. 1 (WSOH No. 1) does seem confusing. Yes, this situation is possible. If you substitute the words "water surface" for "sea" in Paragraph 3.5, Item C, of WSOH No. 1, the statement would be less ambiguous. In the case you describe, the correct coding for a calm sea with a 10-foot swell coming from true north at 8-second intervals would be 30000 36806. Another example of this appears in the General Instructions of WSOH No. 1, page 1-3, at the top of the page.

Your questions about clouds confuse me. I couldn't find any reference to vapour trails in WSOH No. 1. You're right though, vapour trails do require special coding according to the instructions for the synoptic code; however, we deleted them from WSOH No. 1 because they were too confusing. As far as observing clouds at night, it is possible under certain conditions for an experienced observer to make this observation.

I'd recommend though that you simply substitute solidi (/) for the cloud elements at night. Incidentally, you might note that clouds are probably the least important data we request observations of from ships and, if time is a factor and certain groups must go unobserved for an individual report, it should be this group.

I must agree with your final point and add another to it. The codes for Past and Present Weather are both awkward and I'm afraid I can't offer you much help on observing them. Please be assured though that we will do everything we can to simplify the observing code. It may, however, take a while to perform this latter task as any change to the code must be agreed to by members of the World Meteorological Organization.

Thank you for your letter and all the observations you've been sending. If I can be of further assistance, please let me or any of our Port Meteorological Officers know. I've enclosed the latest edition of WSOH No. 1 and our Ship Code Card which may help you in making your observations.

Sincerely,

Robert W. Schoner
Marine Program Leader

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

NEW AMVER SCHEDULES

The Coast Guard duplex radiotelephone frequencies for AMVER and other communications will undergo a change effective January 1, 1978, with the implementation of provisions resulting from the 1974 Maritime Mobile World Administrative Radio Conference. The Coast Guard provides a duplex radiotelephone service on 4, 6, 8, 12, and 16 MHz at selected times, frequencies, and coast stations as part of their responsibilities relating to marine safety and search and rescue. Principal communications consist of the collection of Automated Mutual-assistance Vessel Rescue (AMVER) system reports and weather observations. In addition, the Coast Guard will handle maritime safety-related traffic from all ships having appropriate HF SSB capability in those instances where communications cannot be established on regularly designated safety channels, such as 2182 kHz or 156.8 MHz.

The voice weather observations supplement CW reports received from regular weather reporting ships.

The AMVER system is a maritime assistance program that facilitates and coordinates search and rescue efforts in the oceans of the world. Necessary data are collected by means of a communications system, whereby merchant and other qualified vessels report their sail plans and periodic position reports to the Coast Guard for entry into a computer that maintains dead-reckoning positions of participating vessels throughout their voyage.

Coast Station Schedule after January 1, 1978

Calling and working for ship-shore-ship communications will be in the duplex frequency mode as indicated below. Guard times on the ship station frequencies are in GMT. Frequencies shown are carrier frequencies and emission is single-sideband voice.

Coast XMIT (kHz)	4428.7	6506.4	8765.4	13113.2	17307.3
Ship XMIT (kHz) (Guarded by coast stations)	4134.3	6200	8241.5	12342.4	16534.4
Miami (NMA)		0000-2400			
San Francisco (NMC)	0000-2400	0000-2400	0000-2400	O/R	O/R
Boston (NMF)		0000-2400			
New Orleans (NMG)	0200-1200	0000-2400	0000-2400	1200-0200	O/R
Portsmouth (NMN)	0200-1200	0000-2400	0000-2400	1200-0200	O/R
Honolulu (NMO)	0000-2400	0000-2400	0000-2400	O/R	O/R
Kodiak (NOJ)	O/R	0000-2400	O/R	O/R	O/R
Adak (NOX)	1700-0500	0000-2400	O/R		
Guam (NRV)		0900-2100		2100-0900	

O/R - On Request

Hurricane Alley

Dick DeAngelis
Environmental Data Service, NOAA
Washington, D. C.

The months of July and August spawned no tropical cyclones in either the North Indian Ocean or the Southern Hemisphere. This was not unusual.

JOAN AND "AGGIE" IN THE SOUTH CHINA SEA

When this column began, I promised an occasional sea story. The following narrative by U.S. Navy Commander Taylor, Commanding Officer of the USS AGERHOLM, originally appeared in Fathom, a U. S. Navy safety publication, in 1971. This is an edited version of an interesting and well-written modern sea story.

"AGERHOLM was operating on October 14 [1970] as a screening destroyer in the Tonkin Gulf. Typhoon Joan had crossed the Philippines south of Manila and was heading westward across the South China Sea [fig. 37]. We completed refueling at midnight and were detached for an independent transit to Hong Kong. Early on the 15th some effects of weather were felt as the ship rounded the southern portion of Hainan Island. As we continued northeastward during the forenoon, the weather became increasingly rough with wind and moderate seas (020°)[1] and an occasional large swell (060°). This combination of sea and swell made it impossible to select a 'good' course. Several swells crested on a height even with the bridge. One particularly large swell took the UHF can-type antenna off the top of Mount 51 and threatened to break out the pilot house windows.

"Consequently, we reversed course along our original track. A review of weather warnings indicated this area to be an area of high seas for the next 12 hr. Our intent was to run back along Hainan Island until the unfavorable weather improved and then pro-

[1] All compass headings and bearings are given as true.

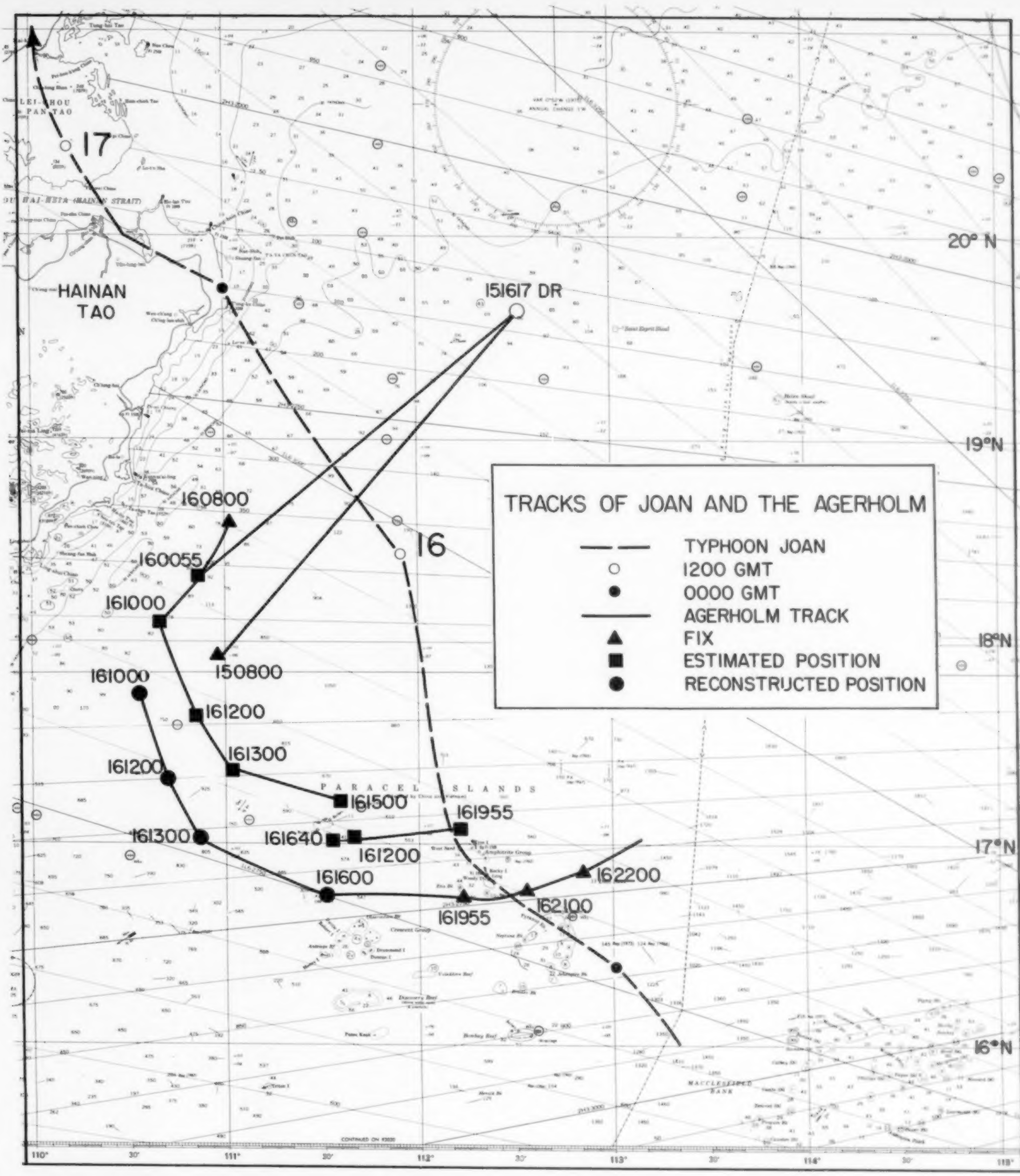


Figure 37. -- The tracks of typhoon Joan and the AGERHOLM.

ceed again to Hong Kong. We did not, at this time, associate the heavy swells with typhoon Joan, reported to be 350 mi to the southeast.

"At about 0130 [LST] on October 16 the ship was running southwest at 12 kn. Wind and seas continued unabated. More typhoon warnings were coming in, and they indicated that Joan would go over land about 90 mi south of Danang. Rather than proceed south and closer to the possible path of the storm, the decision was made to turn about and lie to. I had some qualms about making the turn with the heavy sea state, but word was passed to stand by for heavy rolls and the turn was made without difficulty. Turns for 7 kn were indicated and the ship rode fairly well, with a great deal of pitching. Radar held several peaks on Hainan Island and bearings of these showed the ship

to be making no speed over the ground. At about this time we first associated the heavy swell with typhoon Joan.

"Throughout the rest of the night and for the next 20 hr I did not leave the pilot house. The helm was in constant motion as the helmsman tried to maintain the ship's heading into the seas. At sunrise we were greeted by an endless procession of huge seas sweeping by, most of them with foaming tops from the high wind. Shortly after sunrise the steering alarm sounded and the bridge lost steering control. While we desperately attempted to maintain our heading by engines, the after steering room reported a fire in the electrical junction box and a complete loss of power to after steering. Very fortunately the rudder was nearly amidships and the bridge was able to maintain heading by using the engines until manual steering could be set up. Once this was accomplished, steering was easier (but sluggish because of the time and effort involved in manual steering). The electrical junction box was jury-rigged and approximately 1 hr later the bridge was back in control.

"By 0700 on the 16th we were pitching heavily and winds were gusting to 55 kn. Shortly thereafter the latest report on Joan indicated that the storm had turned and was proceeding northwest directly toward us at a distance of about 180 mi. There was no longer any doubt as to the source of our troubles.

"The answer to our wondering in which direction we should evade was readily arrived at, since we could make no headway in any direction except downwind. Even this might put us across the path of the storm, in which case we might have to run ahead of the storm up into the Gulf of Tonkin, distinctly unfriendly territory.

"The decision to turn the ship downwind was a distressing one to make because I felt she might roll over in the 40-ft seas, even though fully loaded with fuel. Visibility was extremely restricted because of flying spray and mist and it was impossible to pick an optimum time for the turn. All hands were advised of the situation and directed to keep lifejackets ready for immediate use.

"Shortly after 0800 on the 16th I directed the OOD [Officer of the Deck] to bring the ship about. Wind and flying spray made it difficult to see and hear. The OOD immediately put his rudder over and ordered full speed on the outboard screw and a standard bell on the inboard to provide good rudder control. AGERHOLM was caught by a 30-ft swell on the beam as she came smartly around. This large swell simply lifted the ship up and dropped her again, with little rolling motion. I was convinced fully by now that if several large steep swells caught her broadside during the turn she might roll over.

"As we steadied on a downwind course of about 220°, there was a very noticeable air of relief on the bridge. The relative wind intensity dropped to about 35 kn with a corresponding drop in noise, and the ship appeared to be proceeding easily down the face of the large swells. Steering control was somewhat difficult and speed was increased to 15 kn. Immediately thereafter, AGERHOLM had her stern picked up by a large swell and she careened wildly off to the right to broach to in the trough of the swell, heeling over to port at an extreme angle which I estimated to be in excess of 50 degrees. One could have stepped out of the port pilot house door directly into the sea. I had a premonition of the end, but surprisingly enough she righted herself to an angle of about 30 degrees, where she was held by an estimated 60-kn wind. Somehow we were able to regain control; as I remember, it was through an initial burst of speed on both engines followed by a backing bell on the inboard (port) engine that we were able to preclude the same incident from occurring again.

"We quickly learned that with winds of 50 kn or more aft of the beam, the ship was extremely difficult to hold downwind. Each time the ship broached on a sea, or tried to, the wind would push the stern downwind, down the slope of the swell, and force the bow around to windward. The only effective means of preventing this was to use speed to provide rudder control. But here again, excessive speed could easily lead to 'surfboarding' down a swell with a high probability of broaching. Through a nerve-racking trial and error period, we discovered that with the starboard engine ahead standard and the port engine ahead one-third we could easily maintain good helm control. We actually used this engine combination for most of the next 12 hr, until out of the storm's danger area.

"Throughout the entire period we were attempting to keep the seas on the starboard quarter in order to open from the storm's center. Had the seas been on the opposite quarter, the opposite engine combination would have been equally effective.

"Having found a workable means of maintaining our downwind heading, we settled into a routine to ride out the storm. As each large swell passed the ship she would settle into the following trough and appear to be making no way through the water. The succeeding swell would lift the stern and at the same time the bow would bury itself in the trough, with only the jackstaff pedastal remaining visible forward of Mount 51.

"As the ship moved higher on the face of the approaching sea she would slowly pick up forward motion, her progress being marked by the jackstaff proceeding through the white water like a submarine periscope, until finally the bow would surface and the ship would drop over the crest into another trough. During each of these cycles AGERHOLM's speed would appear to increase from zero to an estimated 15 kn.

"It became increasingly apparent that we were now slaves of the storm, being committed to run downwind in an attempt to open the storm center. I spent much of the early downwind period watching huge swells come up astern and coaching the OOD right or left a little to minimize the tendency for these swells to broach the ship. The seas were very large, steep and confused, indicating that we were quite close to the storm center. Large swells routinely came cresting by at a level above the pilot house. Occasionally seas on opposing courses would come together, ejecting gysers 60 ft or more into the air. A look in any direction gave the appearance of a maelstrom in which no ship could survive, and we were in the middle.

"Since reversing course at 0800 we had had no means of navigation and an accurate DR track was almost impossible to plot. By rule of thumb (face the wind and the storm center lies 115 degrees to the right) the storm center was farther north than reported and probably quite close. This estimate was later found to be highly accurate. Of immediate concern was the

fact that the wind was slowly backing, thus AGERHOLM's course was continually shifting to the south and east. We knew that the Paracel Islands were some 60 mi to the southeast. Avoiding these became one of my primary concerns. With the standard/one-third engine combination I assumed our speed to be about 8 kn. As a precaution I calculated our approach to the Paracels at 12 kn and maintained a close watch on the depth-sounder. Radar was useless and visibility at all times was less than 1 mi. At about 1430, somewhat sooner than I had anticipated, the fathometer gave an indication of shoaling water which I correctly assumed to be the Paracel Group. I further assumed, incorrectly, that this would be the North Reef, but I had no idea of where the island lay. Visibility was extremely restricted and every large swell periodically broke into a giant surfline. I conned the ship past this first reef by fathometer information with a distinctly sick feeling in the pit of my stomach, straining to see anything that might be surf, with the intention of immediately bringing the ship about in the event I could identify anything, or if the fathometer indicated rapidly shoaling water. The fact that I could probably make no headway, even if I should successfully make the turn, remained in my mind.

"Soon the water deepened again and I felt security in the knowledge that I thought I knew where we were and when to expect the last remaining island, and we adjusted the ship's head to the left to pass clear. Several hours later the fathometer again indicated shoaling water. We had been proceeding downwind on a course of 100° plus or minus 10°. I assumed that this would be the Amphitrite Group and that AGERHOLM would pass just to the north. Consequently our heading was changed to 070° which placed the wind and seas about 30° on the port quarter, at a point where almost full right rudder was required to prevent broaching. On this heading the wind heeled the ship over to a constant 20-30 degrees, which increased each time a following sea passed. Fathometer indications were consistent with where I thought the ship to be, and it was with a distinct feeling of relief that we passed this island and again entered deep water.

"By dark, AGERHOLM was riding well, having crossed behind the storm center at a range estimated to have been 60 mi. We were able to open the storm on a course of 090°, although seas were still mountainous and the true wind remained between 65-80 kn. At about 1930 on the 16th we had a radar contact at 077°, 16 mi. After an evaluation that the contact had no course or speed, someone wiser than I compared our fathometer reading with the reciprocal bearing and range from Woody Island in the Amphitrite Island group. The depth compared perfectly and as we approached Woody Island the comparison proved correct. Another course change to 110° was made to pass safely. Lincoln Island was detected and passed shortly thereafter.

"Reconstruction based upon these final sightings indicated that we had been making a fairly steady 17 kn, running with the seas on the standard/one-third combination. This was double what we believed our speed to be, and of course put the ship well south of our DR position and into the Paracel Group. Laying out the ship's track in reverse indicated that we had not, in fact, passed North Reef or the Amphitrite Islands close aboard, but that we were obtaining soundings in the relatively shallow waters to the south.

"Maneuvering was still restricted in that we could not turn more than 30 degrees off the downwind course. The wind, however, dropped occasionally to 55 kn and for the first time the barometer increased, having dropped some .80 of an in over the last day and a half to a low of 28.80 [975 mb]. By 2100 on the 16th the ship was riding easily, relative wind was between 35 and 45 kn, backing, with the seas more stable. We were thus able to maintain our desired 090° heading. I left the bridge for the first time in almost 24 hr.

"As I look back, the wind was the predominant factor with which we had to contend. Seas were generally mountainous, but when the true windspeed remained between 50-60 kn it was not too difficult running downwind. Periodically, however, the wind would increase to 70-80 kn. During these periods the seas would quickly increase in height and appear to run in several directions, cresting white foam continuously. Visibility decreased radically and noise intensity increased. Maintaining a downwind heading became increasingly difficult, and the ship would be boarded by successive seas. One could hear and feel each swell as it rumbled from aft along the ship. We were surrounded by white water and flying spray. The total effect was frightening and the question foremost in everyone's mind was, 'When will this end?' or 'How much longer can we take it?' By comparison, when the wind dropped to 40-50 kn it was almost like a Sunday afternoon at the park."

On the Editor's Desk

NEW U.S. COAST GUARD AMVER FREQUENCIES

The masters and owners of all ships, including yachts and fishing vessels, with HF radiotelephone facilities should review and familiarize themselves with the new frequencies of the U.S. Coast Guard AMVER system which are effective January 1, 1978. The new frequencies are given in "Tips to the "Radio Officer" in this issue.

NOAA AWARDS SKYWAVE RADAR CONTRACT

NOAA has awarded Stanford Research Institute a $44,209 contract to make a series of long-range skywave radar measurements of sea conditions in the North Pacific Ocean.

As part of the cooperative study, Stanford Research Institute scientists will take wave measurements for a 12-mo period from their seascatter radar antenna facility approximately 100 mi southeast of San Francisco, Calif.

The sophisticated radar system, nearly 2 mi long, will beam high-frequency radio signals toward the ionosphere--an invisible atmospheric shell 50 to 650 mi above the Earth--which reflects the signals earthward great distances from the antenna. Some of the

signals return to the transmitting site over the same pathways and can be used to infer ocean wave height, length, and direction of travel.

COAST GUARD APPROVES EXPOSURE SUITS

The Department of Transportation has announced that the Coast Guard is issuing, for the first time, approval of exposure suits for survival in cold water. Similar in appearance to a diver's wet suit and made of neoprene foam, the exposure suit completely covers the body and keeps the wearer afloat, warm, and dry (fig. 38). Tests in freezing water have shown that for 24 hr or more the suits can protect against the deadly effects of hypothermia--loss of body heat caused by exposure to cold temperatures.

Approval of the suits is the result of several years' work by the Coast Guard and equipment manufacturers for the Great Lakes Extended Navigation Season Demonstration Program. This program involved efforts of various Federal agencies to keep shipping channels on the Great Lakes open longer during the winter in order to maintain the flow of commerce.

The Coast Guard's primary responsibility in the program was survival equipment, and several projects were initiated to address the problem of protecting the lives of seamen during the frigid winter. Until this time, there were no devices to protect against hypothermia, except the common lifejacket which allowed for only a few minutes of survival in cold water.

Figure 38.--The exposure suit as viewed from the foot. It appears the wearer may have problems if air gets trapped in the legs.

NEW DEVICE SPEEDS HURRICANE INFORMATION

A specially designed communications device connecting a weather research aircraft with a satellite 22,000 mi (35,400 km) in space is ready to provide near instantaneous information about the growth and movement of hurricanes in the Caribbean and southern North Atlantic.

Developed by NOAA personnel, the transmitter relays coded information on pressure, winds, temperatures, and other hurricane-related data to NOAA's National Hurricane Center in Miami in only 15 sec. Transmitting the same information by voice radio from aircraft to a ground station--the normal procedure-- would take anywhere from 5 to 15 min.

The device is an airborne data collection platform which utilizes the data collection capabilities of NOAA's GOES-2 satellite. A somewhat similar piece of equipment, still in the research stage, is in daily use aboard a Pan American 747 as it flies along the airline's worldwide routes.

During the 15-sec journey from the hurricane-hunting C-130 airplane to the National Hurricane Center, the data moves from the aircraft to the satellite, down to a ground-receiving station at Wallops, Va., on to NOAA's Satellite Service headquarters in Suitland, Md., and then to the Satellite Field Services Station in Miami, adjacent to the National Hurricane Center.

The speed at which the digital information is provided to the Hurricane Center is particularly important as hurricanes approach populated areas, which permits personnel to issue appropriate alerts.

Even though there were no Atlantic hurricanes until the end of August this year, the device was tested under actual flight conditions during reconnaissance of a tropical depression. It is planned to install similar transmitting devices in NOAA's two other research aircraft next year.

DROUGHT CAUSES SALTIER WATER IN PUGET SOUND

Puget Sound is saltier these days, and last winter's drought is the probable culprit, according to scientists at NOAA's Pacific Marine Environmental Laboratory. The shortage of rainfall in the Pacific Northwest has reduced the amount of fresh water flowing into the Sound to mix with the ocean's salty waters.

During an oceanographic study of the Sound in March 1977, an increase in water density--mostly salinity--was discovered. The research was part of a larger study of Puget Sound being managed by NOAA's Marine Ecosystems Analysis (MESA) program. The results of measurements of salinity and temperature throughout the Sound have not all been analyzed, but so far they reveal higher-than-normal levels of salinity.

A similar increase in salinity was recorded in 1953. A systematic comparison of the weather conditions then and now has not been made, but there also was a similar dry spell during the 1952-53 winter. In that instance the waters returned to normal the following year.

The focus of the March voyage was the deep water of the Sound. Puget Sound, cut ages ago by glaciers, is actually a series of deep basins, separated from each other, and from the Pacific, by "sills" of shallower bottom. Measurements were made at depths down to 1,000 ft (300 m) by lowering instruments on a cable.

The researchers also deployed current meters and other instruments at The Narrows near Tacoma, Wash., where the estuarine waters of the Sound flow over a sill into a secondary basin to the south. Tidal currents through The Narrows are extremely strong,

Figure 39.--The nuclear-powered icebreaker ARKTIKA ready to leave Murmansk for trials in ice conditions. Photo by M. Kurnosov.

and they exert a sort of pumping action, drawing deeper water from the northern basin and contributing to renewal of the deep water in Puget Sound. When these instruments are recovered, the researchers hope they will reveal something about the nature of this pumping mechanism.

Future cruises are planned to see if the increased salinity persists and to study Admiralty Inlet, where ocean waters enter the Sound over another sill. Processes there determine when denser (either saltier or colder) water from the Pacific crosses the sill and enters the Sound.

SOVIET ICEBREAKER REACHES NORTH POLE

The Soviet atomic icebreaker ARKTIKA (fig. 39) smashed a path through Arctic pack ice to reach the North Pole early on August 17 and became the first surface ship to conquer the top of the world.

After its launching in 1974, the ARKTIKA was described as the world's most powerful icebreaker. The ship is 460 ft long, weighs 25,000 tons, and has two nuclear reactors driving four steam turbines providing 75,000 hp. The first of the nuclear series of Soviet icebreakers was the 16,000-ton LENIN, which has been operating since 1960. A third and still larger ship in the series is the SIBIR which is not yet operational.

The ARKTIKA was under the command of Captain Yuri S. Kuchiev, and the Soviet Minister of the Merchant Marine was aboard. The voyage demonstrated the Soviet Union's increasing capabilities in ice navigation. The presumed route of the ARKTIKA was from Murmansk directly north to the North Pole, passing between Spitsbergen and Franz Josef Land.

The icebreakers have been used mainly to keep open the shipping lanes along the icebound northern coast of Siberia between Murmansk and Norilsk, where large nickel, copper, and platinum mines are located. The 3- to 4-mo summer season has been extended to 6 mo or more.

The crew hoisted the Soviet flag on the ice field and attached a capsule to the staff. Scientists on board made observations during the 15 hr that the ship remained at the Pole. One of the major problems of the voyage was determining when the ship had reached the North Pole. Fog obscured the sun, and the constant daylight obscured the stars. Magnetic compasses are useless owing to the proximity of the magnetic pole. They relied on a radio and satellite navigation system accurate to about 800 yd to fix their position. They had to break through ice up to 12 ft thick on the trip northward.

The trip took 7-1/2 days northbound and 13 days roundtrip for the 3,582-mi voyage. They crashed

through more than 1,200 mi of dense old ice in the central Arctic region. On the return trip the ship cleared the last ice near latitude 80 degrees.

Other nautical ships to reach the North Pole were the U. S. nuclear submarines NAUTILUS and SKATE in 1958 and 1959.

SPECIAL RECOGNITION FOR ANDREAS U.

The India Meteorological Department forwarded a letter and a certificate of "Recognition of Special Service" for presentation to the ANDREAS U. in appreciation for weather observations radioed on May 30, 1975, while in the vicinity of a tropical depression in the Arabian Sea.

The letter is cited below.

India Meteorological Department

Poona, India
June 18, 1977

The Director,
U. S. Department of Commerce,
National Oceanic and Atmospheric Administration,
Environmental Data Service,
Washington, D.C. 20235

Dear Sir:

Your selected ship ANDREAS U. while plying in the Arabian Sea on 30-5-1975 had sent valuable weather observations from the field of depression. As a token of our appreciation of the efforts made by the ship's officers in furnishing the weather reports from the depression area we wish to present the enclosed certificate to the ship. We hope the officers of this ship as well as of other ships of your Voluntary Observing Fleet will continue to extend their valuable cooperation in our rendering efficient and timely warnings to shipping by sending such weather reports in the future also.

It will be appreciated if the attached certificate is forwarded to the Captain of the ship.

Yours faithfully,

P. S. Pant
Deputy Director General of Observatories (Forecasting)

SCIENTISTS WEIGH NUCLEAR WASTE DISPOSAL IN ATLANTIC OCEAN CANYONS

The possibility that radioactive wastes from nuclear power plants could be buried safely in cracks in the Atlantic Ocean floor should be explored further, accorging to scientists Peter Rona of NOAA and Karl E. Turekian of Yale University.

As debate over a safe, permanent disposal site continues, radioactive wastes are accumulating in temporary repositories. The search for a safe site is difficult because a place must be found where the wastes can lie undisturbed for as long as 250,000 yr. During that enormous span of time, no earthquake may jar them, living creatures cannot be exposed to them, and they must not be carried away by ocean currents or underground streams.

Plutonium sealed in canisters and dropped into fracture zones in the eastern Atlantic might be buried by sediments. Should the canisters someday leak, the materials inside would be imprisoned by chemical processes in the deep-ocean sediments and waters themselves. Though more study is needed, what the scientists now know of the geological, chemical, and oceanographic characteristics of the fractures suggests they might make a safe burial ground.

The parallel fracture zones, deep canyons running for hundreds of miles across the Atlantic basin, slice diagonally through the Mid-Atlantic Ridge, the ocean's central spine where molten material wells up from the Earth's interior to form new crust. The largest of these enormous canyons has floors 6 mi wide and walls 1 or 2 mi high, a capacious natural prison. The fractures are deepest at the Mid-Atlantic Ridge, and with the exception of an active portion that crosses the central spine of the Mid-Atlantic Ridge, the fracture zones are inactive along most of their length.

Sediment accumulates quickly on the floors of the fractures by filtering down, particle-by-particle, from above and is augmented by minor avalanches of sediment which has accumulated on the walls of the fracture. A layer of sediment only 3 in thick is enough to isolate the material below from most natural disturbances by organisms at the sediment surface.

The amount of sediment cover anticipated at potential burial sites could be tested by assaying the sediments already there for natural radioactive elements with different half lives (the time required for half of a quantity of a radioactive element to decay into a stable one). This would give a rough estimate of the age of the latest avalanche deposit.

Even if radioactive particles did work their way to the sediment surface, they would not rise far into the water column. Iron and manganese released from the ocean floor in those regions combine with oxygen in the waters and sink again to the bottom, picking up heavy metals along the way.

Finally, the researchers argue, the circulation of the Atlantic is such that even if plutonium somehow escaped all these other restraints and worked its way into the water column, it would be a long time before it reached the surface of the ocean, where it could begin to affect humanity. This is especially true of the eastern basin of the ocean.

The length of time between release of a substance to the ocean bottom in the eastern Atlantic and its arrival at the surface will be one of the longest in the ocean system, perhaps 1,000 yr. The time required for wandering of a water parcel from the deep ocean bottom to the ocean surface, where man's main concern lies, porvides an additional barrier should material escape from a container, the sediment, and the sediment-water interface.

The scientists emphasize that before any decision to bury nuclear wastes in fracture zones is made, more intensive study of the sedimentologic and oceanographic properties of the areas is needed.

This work was supported in part by the National Science Foundation and the Energy Research and Development Administration.

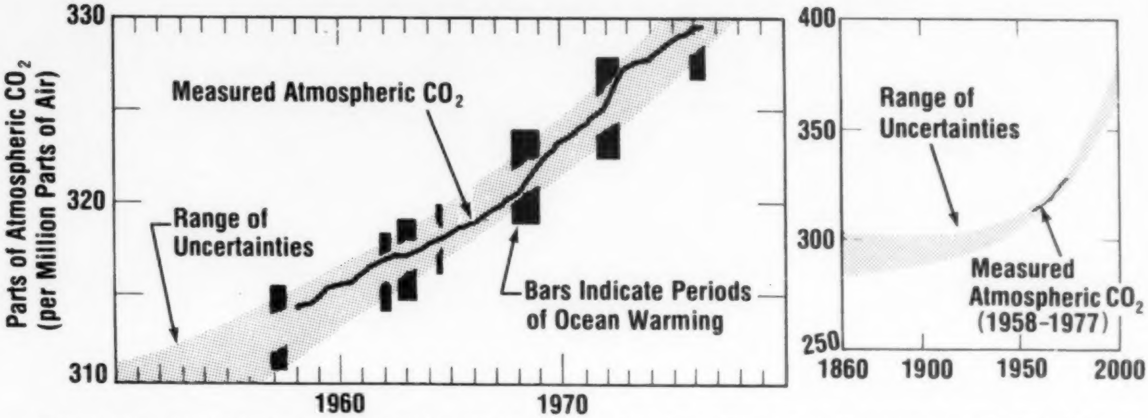


Figure 40.--Atmospheric carbon dioxide--NOAA/Scripps data from Mauna Loa Observatory 1958-77, 12-mo running mean values.

ATMOSPHERIC CARBON DIOXIDE MONITORS SHOW GLOBAL INCREASE

A small, persistent rise in global concentrations of carbon dioxide observed by NOAA and Scripps Institution of Oceanography scientists over the past 2 decades may hold important implications for future climate.

Taken at the Mauna Loa Observatory in Hawaii, the series represents the longest, most nearly continuous record of measured atmospheric carbon dioxide in existence. It is also a major piece of evidence for scientific concern whether continuing increases in atmospheric carbon dioxide will amplify the so-called "greenhouse effect," warm the Earth, and cause significant changes in global climate.

The unique series of measurements contain minuscule, hard-to-explain fluctuations in the rate at which this increase is occurring. Understanding these fluctuations is an important key to defining the human and natural factors behind the general carbon dioxide increase and to predicting future carbon dioxide concentrations.

The 18-yr-long Mauna Loa record indicates that atmospheric carbon dioxide has increased from about 314 parts per million in 1958 to about 330 parts per million in 1976--an increase of about 5 percent (fig. 40). It also suggests that the annual rate of increase is growing. From 1960 to 1965, for example, measured carbon dioxide at Mauna Loa increased from about 315 to about 318 parts per million, an increase of just under 1 percent. But between 1965 and 1970, Mauna Loa measured an increase of slightly more than 1 percent, and the increase was 1.2 percent between 1970 and 1975.

The Mauna Loa record essentially is duplicated by other measurements taken at the South Pole, Barrow, Alaska, American Samoa, and by Sweden and Australia.

Because virtually all carbon dioxide added to the atmosphere comes from the combustion of fossil fuels like coal, natural gas, and petroleum, and possibly from the destruction of forests, scientists base their predictions regarding increased carbon dioxide on estimates of carbon dioxide values in 1860, when the industrial revolution began.

Recent typical estimates of what atmospheric carbon dioxide values were at that time range from 285 to 305 parts per million. Another estimate indicates the preindustrial value may have been as low as 265 parts per million. If these values are correct, the NOAA-Scripps measurements at Mauna Loa show the increase since 1860 is between 8.2 and 13.8 percent, a broad range of uncertainty.

The carbon dioxide record from Mauna Loa, however, does not show the consistent year-to-year increase one might expect if the rather steadily increasing fossil fuel burning were the only factor affecting the rise. Studies have shown that the departures from this hypothetical steady increase are correlated with sea surface temperature anomalies of tropical oceans. Apparently when the ocean warms, it releases carbon dioxide into the atmosphere.

At the present time, a number of studies are using the 18-yr observational record to try to determine what portion of the carbon dioxide released from fossil fuel burning over that period has remained in the atmosphere. The potential problem with this is that natural fluctuations in carbon dioxide associated with the rise in ocean temperature changes are combined in the observational record with carbon dioxide from fossil fuel burning. This uncertainty has a significant effect on assessing the observed increase in atmospheric carbon dioxide.

NOAA, UNIVERSITY SCIENTISTS PROBE DOUBLE WATERSPOUTS

Laser probes of waterspouts, the mild oceanic cousins of tornadoes, indicate that some spouts may sometimes be two funnels, one inside the other, each rotating at its own speed.

Double-walled waterspouts were among the recently announced preliminary findings of a study begun last year that probed the seagoing funnels off the Florida Keys with a laser beam aboard a small aircraft.

The laser is part of a novel instrument that scientists of NOAA and Colorado State University used to measure windspeeds in waterspouts from a Cessna 207.

Double-walled spouts have been observed before, but their winds had not been measured until this study. It was previously thought that the double-funnel effect was caused by variations of moisture in the spout, with

the visible wall being formed simply by denser concentrations of water.

With the laser device it was possible to measure windspeeds and identify the dynamic difference--the difference in velocity within the spout that indicates two cylinders rotating about a common axis.

Preliminary analysis of the data suggests that the two vortices of a double spout are in fact two separate, concentric funnels which rotate in the same direction, but at different speeds.

The scientists made the waterspout measurements in a project sponsored by the Nuclear Regulatory Commission, which hopes to use the results to understand severe weather phenomena. The chief tool was a Doppler lidar (laser radar) designed and built at NOAA's Wave Propagation Laboratory in Boulder, Colo. The instrument uses laser-generated beams of infrared radiation to gauge windspeeds. By bouncing these beams of known frequency off a distant moving object, such as wind-borne dust or cloud droplets, and measuring the frequency shift (doppler shift) of the return signal, the scientists can calculate the velocity with which the target is moving toward or away from them.

For 30 days last August and September, waterspout flights were made from Key West International Airport. When they found a waterspout, the researchers scanned it with the laser beam. They could usually get within 660 to 1,640 ft of the spout. As the team on the Cessna probed the waterspout from a safe distance, a specially instrumented aerobatic T-28 from Colorado State University flew through the spout, obtaining on-the-spot measurements to compare with those obtained by the remote sensor.

Only part of the data has been analyzed, but the maximum rotational velocity found so far was 56 mi (90 km) per hr. The waterspouts ranged in size from 13 ft to giants 100 ft across. All of them occurred at least 7 mi from shore.

The researchers were also able to measure the turbulence on the upwind side of the waterspouts. This turbulence occurs because the waterspouts often move more slowly than the prevailing breeze. This has been found to be true of dust devils as well. Such turbulence was expected from theory, but the NOAA team was able to document the actual quantity of the turbulence. Additionally, the team observed waterspouts rotating both clockwise and counterclockwise, unlike tornadoes, most of which are counterclockwise. Dust devils are about evenly divided.

NOAA SCIENTISTS MONITOR TESTS OF DEEP SEA MINING SYSTEMS

The first operational tests of systems for gathering manganese nodules from the floor of the ocean will begin late this year in the central Pacific Ocean when NOAA scientists measure the cost of deep sea mining to the marine environment.

Four international mining consortia plan systems tests over the next several years, according to NOAA's Environmental Research Laboratories. The first to field its gear will be Deepsea Ventures, the operational arm of Ocean Mining Associates. Its activities will be monitored by NOAA scientists involved in the Deep Ocean Mining Environmental Study (DOMES, using scientific instrumentation on the NOAA research ship OCEANOGRAPHER (fig. 41). DOMES scientists also will be aboard the two Deepsea Ventures mining ships.

Figure 41.--The NOAA ship OCEANOGRAPHER.

The dual efforts of the mining tests and the environmental study represent for both industry and science the second step in harvesting the roundish lumps of rock containing high concentrations of iron, manganese, copper, and nickel. While industry has been working to develop techniques for collecting this wealth, DOMES researchers have been engaged in baseline studies of the state of the waters, life forms, and sea bed, prior to mining. These studies have focused on three sites in the central Pacific judged to be representative of the range of environmental regimes that mining might affect.

The tests to be monitored will be of hydraulic systems for mining the nodules. A collector, or dredgehead, will travel along the sea floor, drawing in water, nodules, and whatever else lies in its path. The system will separate the nodules from other material, discharging much of the latter near the sea floor while pumping the nodules upward through a pipe to a ship. The remainder of the excess material will be discharged at the sea surface.

Over a 20-day period the scientists will concentrate on the effluent discharged at the surface. Researchers aboard the mining ships will note how, where, and how fast the materials are discharged into the sea; the nature of the discharge--its temperature, salinity, concentration of solids; and, finally, what is done with the nodules that are collected or discarded.

From the OCEANOGRAPHER, DOMES scientists will track the surface plume as it leaves the mining ship. They will try to define the growth of the plume in three dimensions--by collecting water samples and analyzing them for telltale traces of effluent material, making measurements of the clarity of the water at different places, and probing the water with sonar. The shipboard scientists hope to supplement their observations with images from satellites.

Even after the mining test has ended, the DOMES research will continue, watching the site to see how it recovers and how long the process takes. NOAA scientists plan to remain on site for a time following completion of the mining test, as the sediments settle again to the bottom or are dispersed by the currents,

and will return for followup studies at several-month intervals for as long as mining effects persist.

In future tests the scientists hope to monitor the effects of the dredgehead on the sea floor and the waste plume discharged into the bottom waters. They want to observe how rapidly the collector moves across the bottom, how its movement clouds the waters, and how deep a scar it leaves. In addition to the same observations used to track the surface plume, the scientists will collect bottom samples and lower underwater cameras to record events on the sea floor.

LETTERS TO THE EDITOR

PACIFIC CARRIER EVADES HURRICANE DOREEN

The narrative below was sent by Paul A. Arnerich, retired Port Meteorological Officer, San Francisco, Calif., as related to him by Captain Gojko Gospodnetic of the PACIFIC CARRIER.

"The 13,567-ton motor vessel PACIFIC CARRIER, commanded by Captain Gojko Gospodnetic, departed Long Beach, Calif., on August 13, 1977, bound for San Marcos Island in the Gulf of California. At 0000 August 15, some 400 mi northwest of hurricane Doreen, the vessel and storm were approaching each other head on (fig. 42). Captain Gospodnetic took evasive action with a series of course changes that put the vessel on a general heading 45 degrees to the right of his original track. The new track eventually took a semicircular path with a radius of approximately 150 mi to bring the vessel just south of Cape San Lucas and into the Gulf of California.

"At the closest point of approach (CPA) the PACIFIC CARRIER was about 150 mi west-southwest of Doreen. Near Cape San Lucas the ship crossed the storm's wake about the same distance behind the storm.

The officers took observations every 3 hr, and all were transmitted to the National Weather Service. Because of the early warning and the evasive action, very little bad weather was encountered. Winds did not exceed 25 kn, and the seas and swells were under 6 ft.

"Though there was about a 14-hr delay in arriving at their destination, no damage was incurred to the ship which was in ballast. Damage possibly could have caused an even greater delay.

"While the ship's log and weather observations would be of little value in studying extreme effects of a hurricane, they are a good example of how a prudent mariner can minimize damage and losses by careful attention to meteorological warnings. This would not be possible without the accurate and frequent transmission of weather observations to aid the National Weather Service in providing warnings."

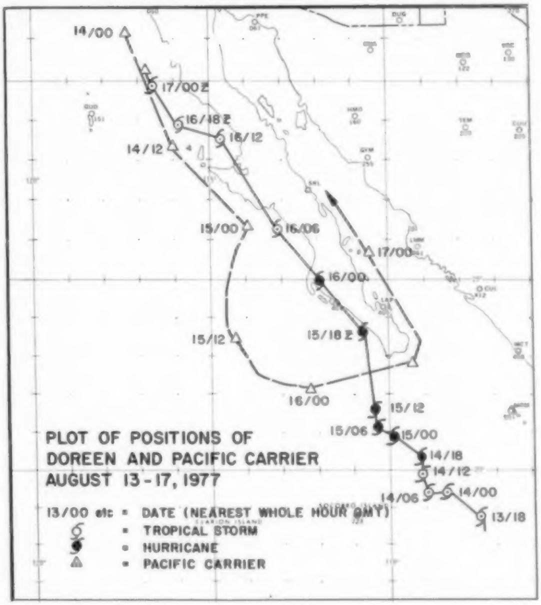


Figure 42.--The tracks of hurricane Doreen and the PACIFIC CARRIER.

REPORTING OF MARINE WEATHER OBSERVATIONS

The following letter was sent to all masters of Exxon Company-operated oceangoing vessels by Torrance Inman, Port Captain, Exxon Company, Houston, Tex., following a seminar on "Marine Weather and Ocean Systems--Today and Tomorrow" held in New York in September 1977. The conference was sponsored by the Maritime Association of the Port of New York. Although many subjects were covered in the presentations, the recurrent theme during the discussions, especially by the meteorologists, was the continuing requirement for meteorological observations and for more observations.

EXXON COMPANY, U.S.A.
Post Office Box 1512 Houston, Texas 77001

October 3, 1977

Reporting of Marine
Weather Observations

TO MASTERS OF EXXON COMPANY
OPERATED OCEANGOING VESSELS

During a recent meeting in New York on the subject of Marine Weather and Ocean Systems, the fact was repeatedly emphasized by the National Weather Service representatives that they were not receiving sufficient timely data from weather observing ships at sea. During further discussion of this subject, certain basic problems were noted. They are:

1. Ships fail to make and report observations on a regular basis--that is, some only think it necessary when the weather appears threatening or a nearby disturbance has been reported.
Weather reports from observing vessels should be completed on a regularly scheduled basis and the reports sent to the Weather Service as soon thereafter as possible to assure that the weather forecaster has sufficient current data to feed into his evaluation in making his forecast.

2. Reporting vessels have the misconception that they are not expected to make and report observations when they are 20 or 25 miles off land. The Weather Service would like vessel reports from Departure to Arrival even if steaming 2 miles off the beach. This near-shore weather data is important to the weather forecaster in completing his overall area forecast, and it is necessary that he have this data at hand to analyze and evaluate when putting his area forecast together.

3. Ship's personnel complete the observation but do not report because the Radio Officer may be off duty.
It is important that masters manage the schedule of the Radio Officer to allow the vessel observations to be transmitted on a timely basis.

4. Observations may be completed and reporting messages filed with the Radio Officer, but due to his schedule it may be 4 or 5 hours after time of observation before the Weather Service receives the report.
The Radio Officer's schedule should be managed to entail minimum delay of the completed transmission to the Weather Service from time of vessel's observation.

5. Erroneous reports are received from some vessels, either due to errors in completing observations or errors in transmission of message.
An error of this type is usually detected and the report discarded. This may mean that the Weather Service will not have any vessel observation from a considerable area of ocean, so please be careful.

It is vital that the National Weather Service obtains sufficient ongoing data from surface vessels throughout the coverage areas in order to make accurate forecasts for these particular areas. Generally, the more accurate data available throughout the forecast area, the more accurate the forecasts will be. The observations and reports completed aboard your vessel should be timed in accordance with your vessel's reporting schedule, provided by the Weather Service information aboard, so that the data arrives at the Weather Service in sufficient time to be included in the analyst's forecast. The Weather Service depends on timely accurate data from the ships at sea to enable them to make continuing accurate marine forecasts.

We ask that you give particular attention to this problem aboard your vessel in order to improve our fleet participation in the weather-reporting program. This in turn will enable the National Weather Service to improve their marine forecasting for the safety of ships at sea.

Very truly yours,

Torrance Inman
Port Captain

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 44-47], climatological data from U.S. Ocean Buoys [table 7], and gale and wave tables 8 and 9), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

May and June 1977

SMOOTH LOG, MAY 1977--May was an inactive month over the North Atlantic Ocean and the eastern United States. Cyclones developing over the Great Plains were farther west and tracked more northerly than normal. They also tended to dissipate before reaching the water. The primary paths of the relatively few storms over the water were from Nova Scotia toward the Denmark Strait and from east of Cape Cod toward Scotland. There was one long-lived storm which originated south of James Bay and traveled to the east coast of France.

According to the climatological normal, the monthly mean sea-level pressure gradient for May is the least of any of the 12 months--10 mb. This month the mean gradient was tighter with a 17-mb difference between the low- and high-pressure centers. The primary Low was 1008 mb north of Notre Dame Bay. The Azores High was 1025 mb near 35°N, 27°W, about 300 mi northeast of its normal location.

There were two anomalous Lows along the eastern slopes of the Rocky Mountains reflecting the storm pattern in that area. A negative 8-mb anomaly center dominated western Canada. Another anomaly center of minus 6 mb was over Newfoundland. The pressure over the northeastern ocean was higher than normal again this month, with a positive 7-mb center between Iceland and Scotland.

There were marked differences from climatology in the upper-air flow. The upper-air Low, which is usually near Devon Island (75°N, 80°W), dropped to east of Hamilton Inlet (55°N, 50°W). In conjunction with a ridge over central North America, this produced a deep trough off the east coast of the United States with more pronounced ridging over Iceland and Greenland. Southeast and below this ridge there was an anomalous Low over England.

Extratropical Cyclones--A frontal wave formed on a cold front near the tip of the Gaspe Peninsula on the 3d. At 2100 the WASHINGTON TRADER was east of the front with 45-kn winds from 240°, the seas were 18 ft and the swells 25 ft. Six hours later, the winds had shifted to the north-northeast at 40 kn west of the front, and the seas were 16 ft. The LOW quickly formed a large circulation and absorbed another frontal wave moving northward along longitude 45°W. At 1200 on the 4th, it was 994 mb south of Belle Isle. The ROBERT E. LEE was 700 mi south of the center with 40-kn winds as she approached the front. Other ships in the vicinity of 50°N also experienced winds of 40 kn. On the 5th, the ATLANTICA MILANO found the 40-kn isotack southeast of Sable Island.

At 0600 on the 6th, the KARAKOUMY was very near the center of the LOW with 60-kn winds. At 0600 on the 7th, the SUGAR CRYSTAL near 48°N, 33°W, reported an astonishing 80 kn from the south in the southeast quadrant of the storm. On the 8th the 992-mb LOW was drifting northward; it was absorbed by another LOW approaching from the southwest on the 9th.

This was the LOW that tracked from near James Bay to eastern France. On the 7th high pressure moved south out of central Canada, and this low-pressure center was analyzed on the 0000 chart of the 8th west of James Bay. By 1200 on the 9th, it was centered just south of Long Island at 996 mb. At 1800 the ARECIBO was steaming toward New York with 40-kn northwesterly winds. The ALERT was north of the center early on the 10th with 45-kn winds from the northeast, and a SHIP in the Gulf of St. Lawrence fought 50-kn winds from the north. The MORMACTIDE (38°N, 66°W) was fighting 45-kn westerly winds with 25-ft seas accompanied by 33-ft swells. Boston had .5 in of snow--the latest snow has fallen there since records began in 1870. There was heavy snow in some parts of Massachusetts and Connecticut--15 in at Becket; Ashfield, 12 in; Ashburnham, 10 in; Norfolk, 13 in; and Colebrook, 10 in.

The storm was moving northeastward toward Newfoundland when the CG10 found winds of 50 kn on the 11th in the Bay of Fundy. The MARIA U., south of the center at 35°N, 66°W, was headed into 50-kn winds, 20-ft seas, and 23-ft swells. Only gale-force winds were reported until the 13th when the storm was near 56°N, 38°W, at 1200. The CEDYNIA found 56-kn winds from the west at that time near 45°N, 47°W. The storm crossed the west coast into southern France and dissipated on the 17th.

This LOW over New Brunswick on the 13th was left

behind from the circulation of the LOW above. It expanded quickly as the first LOW moved eastward. The USCGC TAMAROA (40°N, 68°W) was tossed about by 76-kn westerly winds. On the 14th two ships coded as CARD and RICH both reported 50-kn winds from the north just south of Sept-Isles. At 1200 the LOW was 986 mb near Sidney, Nova Scotia.

The storm was drifting northeastward very slowly and weakening, but late on the 15th its forward motion picked up. As it approached the Denmark Strait on the 17th, it again intensified; at 1200 it was 984 mb near 62°N, 37°W. The winds were only in the 20-kn range. The LOW moved up the eastern coast of Greenland into the Arctic Ocean.

As the previous LOW moved into the Denmark Strait, a LOW moved southeastward out of northern Canada into the Labrador Sea. Another weak LOW formed near Belle Isle, and the two combined slightly east of Belle Isle at 0000 on the 18th. At 1200 a SHIP north of Sable Island radioed 45-kn northerly winds. On the 19th at 1200, the storm was near 56°N, 40°W, at 992 mb and turning northward. OWS Charlie was riding 13-ft seas on the 20th, and the ARNI FRIDRIKSSON (62°N, 33°W) reported 44-kn southwesterly winds through 1800. No seas were reported. On the 21st the storm was over the Greenland Sea.

A LOW moved across Canada and was over Labrador on the 25th. As the occlusion moved over the Gulf of St. Lawrence, a closed circulation developed; and at 0000 on the 26th, it was the primary LOW. At 1200 the central pressure was 992 mb near St. Pierre Island. The GREEN HARBOUR was south of the center near 39°N, 55°W, with 56-kn west-southwesterly winds. The KUNUNGUAK was south of Kap Farvel with 58-kn easterly winds and 23-ft seas on the 27th. Two Canadian vessels reported 40-kn winds over the Gulf of St. Lawrence. The GREEN HARBOUR sailing eastward at 1200 was hit by what was coded as 88-kn southerly winds near the front at 44°N, 46°W. The KOHFUKUSAN MARU found 45-kn westerly winds 7° longitude to the west which continued for the next 12 hr. The MARINE ATLANTICA (46.7°N, 59.7°W) had heavy snow showers with 67-kn northwesterly winds at 1800. The EXPLORER was sailing with 20-ft swells near 39°N, 56°W, at 0000 on the 28th. At 1200 the 984-mb LOW was near 51°N, 53°W. East of the center a ship had 40-kn winds and 20-ft swells. At 0000 on the 29th, another ship had 23-ft swells near 42°N, 53°W. Later in the day a frontal wave moved off the East Coast and south of the LOW, weakening the storm as it drifted northward. On the 31st it turned northeastward to dissipate south of the Denmark Strait.

Casualties--The 51,046-ton Liberian bulkcarrier ARGONAUT, Antwerp for Seven Islands, lost her steering in a northerly gale 100 mi southeast of St. John's, Newfoundland. The 73,492-ton Greek tanker CLASSIC ran aground in fog in River Jade on the 9th.

SMOOTH LOG, JUNE 1977--The predominant oceanic weather feature this month on the 30-day mean sea-level pressure chart was high pressure. The Bermuda-Azores High at 1025 mb was centered near 32°N, 39°W, not far from its climatological position. Ridges normally extend westward and northeastward. This month the northeastward ridge was more pronounced than usual and bulged more to the north, virtually wiping out the 1009-mb center of the Icelandic Low. There were two low-pressure centers of some significance, a 1010 mb near Montreal and a 1011 mb over Cumberland Sound.

There were two anomaly centers worthy of mention: a positive 9-mb center south of Iceland and west of Ireland, a result of the extension of the ridge into the domain of the Icelandic Low; and a negative 3-mb center off Cape Cod and south of Cape Sable from the influence of the anomalous LOW over New England.

There was not as much obvious difference from climatology in the upper air flow at 700 mb as at the surface. The trough off the east coast of the United States was more pronounced as was the ridge west of Europe and the trough immediately east of the ridge. This resulted in lower than normal heights off the U.S. East Coast, higher than normal over the eastern ocean, and lower than normal over Iberia.

The storm paths reflected the pressure pattern and its anomalies. The major storm path that affected mariners moved across the northern United States and southern Canada to off of the northeastern coast. After passing south of or over Newfoundland, the storms fanned out with no primary path. There were several cyclones that formed over the ocean. Two cyclones had distinctive southerly components to their tracks over the eastern ocean.

There were no tropical cyclones this month.

Extratropical Cyclones--The cyclones that did develope were generally weak and no real problem to large ships. The first week there was a large HIGH centered off Ireland. A LOW was pushing against the underside of the HIGH. On the 2d and 3d, the EXPORT PATRIOT was sailing westward along 46°N and between 36° and 39°W with gales of over 35 kn and waves up to 15 ft hammering her starboard side. On the 3d the original low center near latitude 46°N collapsed, and another formed near 40°N. At 1800 the NEW ENGLAND HUNTER at 48°N, 37°W, had 51-kn easterly winds. The LOW moved westward with the easterly flow south of the HIGH and turned southward late on the 4th. At 1800 on the 4th, the MEONIA, near 44°N, 35°W, was sailing with 54-kn easterly winds and 13-ft waves. The center of the HIGH crept slowly westward and was elongated by the 5th. At 1200 the KLAUS LEONHARDT (42°N, 34°W) encountered 40-kn gales. On the analysis of the 6th, the HIGH had split into three centers and the LOW was only a trough.

Low pressure controlled the weather over the United Kingdom and Scandinavia and a stationary front lay along 60°N on the 5th. The analysis at 1200 showed a closed LOW south of Iceland. This tightened the gradient between its center and a 1032-mb HIGH centered on 50°N. At 1800 Ocean Weather Station Lima measured 35-kn gales, and at 0000 on the 6th, the gales had increased to 50 kn with 16-ft seas. Lima was also reporting rain showers. The LOW was 996 mb near 57°N, 12°W. The cyclone was moving southeastward and expanding. Gales were blowing in the western semicircle with seas up to 20 ft. At 1800 a ship near the center reported swells of 23 ft near 51°N, 06°W.

By the 8th this LOW had absorbed the other centers

Figure 43.--The remains of the Oceanview Park Fishing Pier can be seen after a vicious spring storm hit the Norfolk area. Wide World Photo.

and was moving northward along the coast of Norway.

A weak front moved off the east coast of the United States on the 3d, and a wave formed east of Long Island. The wave moved northward along the front to Nova Scotia, where it stalled until the 5th. On the 6th it was moving southeastward, and a few gales were reported early in the day. Another LOW was moving across the Great Lakes. The combined LOWs had a large circulation which stretched from the central Great Plains to midocean. The BARON MACLAY(46°N, 53°W) was pounded by 54-kn winds at 1800, and a ship on the St. Lawrence River reported 52-kn winds. At about 2000 the western LOW moved across the Delmarva Peninsula, and at 2030 severe thunderstorms struck the area with gusts to 85 kn. Many sailboats were overturned, and the 42-ft fishing party boat DIXIE LEE II capsized when she was hit by 15-ft waves off Norfolk in the Chesapeake Bay. Thirteen of the twenty-seven people on board died. Hail the size of golf balls was reported in some areas, and a hangar at the airport was severely damaged. The storm destroyed 600 ft of a fishing pier (fig. 43), and the roof of an apartment building near the pier was blown off. Several tornadoes were reported around the Norfolk area. Heavy rains of 1 to 1.5 in were reported in as little as half an hour. The LOW turned northeastward again on the 7th. The TOPDALSFJORD reported 63-kn winds northeast of the center and past weather of thunderstorms. On the 8th the western LOW was the major cyclone as it turned northward to the Labrador Sea. The LASH PACIFICO near 40°N, 60°W, slightly east of the cold front, reported 41-kn west-southwesterly winds and 10- to 15-ft waves. The eastern LOW raced east-southeastward under zonal flow. On the 9th and 10th the LOW stalled south of the Azores. It dissipated off the African coast on the 11th.

This storm originated near Winnipeg, Canada, on the 6th. On the 10th the center crossed the coastline near Atlantic City, N.J. At 1200 the first strong wind report of 46 kn was transmitted by the AMBARTCHIK off Cape Cod. The DORIC sent a special report at 1600 of measured 45-kn winds near 37°N, 70°W, southwest of the center. The winds had shifted to the northwest with 16-ft seas as she moved into the Gulf Stream 8 hr later. At that time the 996-mb LOW was near 40°N, 70°W. There were several 35- to 45-kn gale reports within 100 mi of 39°N, 71°W. The highest seas and swells were 20 ft. On the 11th, 12th, and 13th the cyclone moved slowly northward to New Brunswick and weakened. On the 14th it was headed northeastward.

A LOW formed east of Kap Farvel on the 11th. As the front moved eastward, another low center formed in the trough near 52°N, 25°W, on the 12th. This LOW moved southeastward, and at 0000 on the 13th the STAGHOUND west of the center reported 36-kn northerly winds. On the 14th ships were observing thunderstorms and waves of 15 ft. At 1800 the 1006-mb LOW was near 41°N, 23°W, and the SEALAND PRODUCER 120 mi west of OWS Romeo measured 45-kn easterly winds with 15-ft seas.

The LOW continued to drift in a southerly direction with the higher seas and winds north of the center. On the 17th it turned toward the northeast and disappeared near the Bay of Biscay.

On the 16th a front curved from Iceland to South Carolina. The pressure gradient was weak between it and the coast of North America, and stable waves were moving along the front. At this time a LOW which had originated over the St. Lawrence Valley moved over Newfoundland. At 1200 on the 17th, a double LOW cyclonic circulation was east of Newfoundland. Two ships south of the southern center reported 35-kn gales along the trough line. On the 18th the LOW consolidated near 54°N, 50°W, at 990 mb. The USCGC EVERGREEN (52°N, 52°W) had 44-kn northwesterly winds and 21-ft seas. The C. P. TRADER was east of the LOW with 37-kn gales and 16-ft seas. There were isolated minimal gale reports as the cyclone wandered over the Labrador Sea before turning northeastward. On the 22d OWS Lima measured 35-kn winds and 15-ft waves as the storm neared 63°N, 35°W. On the 23d it broke into two centers and moved eastward over the Norwegian Sea.

This LOW formed at the point of occlusion of a frontal system as it moved off Long Island late on the 26th. At 1800 the FNYC was hit by 52-kn winds from the south near 40°N, 58°W. At 0000 on the 27th, the DORIC had 42-kn gales on her starboard side as she sailed down the coast. The FNYC was about the same distance ahead of the storm at 1200 with 44-kn winds. At 1200 on the 28th, the 1000-mb storm was centered near 42°N, 58°W. The FNYC, still sailing eastward along latitude 41°N, had 38- and 56-kn winds at longitudes 46°W and 42°W at 0000 and 1200, respectively.

The storm weakened as it passed near the Grand Banks, but it gained new life after passing into midocean. At 1200 on the 30th, the 992-mb LOW was near 54°N, 36°W, and the PAMIR was near 53°N, 37°W, with 994-mb pressure and 42-kn winds. At 1800 OWS Charlie measured 44 kn. At the same time on July 1 the DISCOVERY (58.6°N, 31.5°W) had 995-mb pressure, 45-kn northerly winds, and 25-ft seas. On the 2d, a ship 300 mi south of the LOW had 20-ft swells.

On the 3d the LOW was stacked vertically with the upper air LOW and remained stationary near 60°N, 20°W, until it dissipated on the 5th.

Casualties--The 8,300-ton Canadian icebreaker ferry WILLIAM CARSON sank early on the 3d after striking an iceberg in the Strait of Belle Isle. All 128 passengers and crewmembers were rescued by helicopter and the Coast Guard icebreaker SIR HUMPHREY GILBERT. The drilling rig OCEAN MASTER II while under tow sank in rough seas off the Nigerian coast the second week of the month.

During late May and early June the PAUL LORENZ RUSS (4,475 tons) suffered ice damage in the Strait of Belle Isle while bound for the Great Lakes. The 1,450-ton CHEMIE CARRIER arrived Curacao with heavy weather damage sustained on the 17th during a voyage from Houston.

Four men in a banana-shaped leather boat reported that everything was okay while 250 mi north-northeast of St. Anthony, Newfoundland, on the 15th. On the 14th they were caught in pack ice, but a fishing vessel escorted them 15 mi through the ice. They were on the final 250-mi leg of a 4,000-mi voyage across the Atlantic from Ireland to Newfoundland. The crew was trying to demonstrate that St. Brendan, a famous early medieval Irish navigator, could have discovered America 1,000 yr before Columbus.

Smooth Log, North Pacific Weather

May and June 1977

SMOOTH LOG, MAY 1977--The storm paths across the North Pacific were widely diversified. The storms normally track northeastward off the east coast of Japan to the Aleutian Islands and into the Gulf of Alaska. This month the major connection with climatology was a general northeasterly direction. There was no favorite area of cyclogenesis as storms formed all across midocean. The Gulf of Alaska was still the favorite destination. Several storms had definite southerly components to their tracks, and more than usual were stationary at some point during their existence.

The mean sea-level pressure over the North Pacific closely matched climatology. The pressure centers were slightly more intense, with the Aleutian Low 2 mb lower at 1007 mb and the Pacific High 3 mb higher at 1026 mb. The Aleutian Low was over the Bering Sea at 60°N, 170°W. The Pacific High was near 32°N, 145°W. There were anomalous low centers along the eastern slopes of the Rocky Mountains.

The significant anomaly centers were a negative 5 mb over the Bering Strait and a negative 8 mb over central Canada. There was also a large flat area of positive 2- to 3-mb departure that stretched from the center of the Pacific High to the Sea of Okhotsk.

The upper-air pattern was mainly zonal with major troughs along both coasts.

Tropical storm Ava formed on the 25th for the first tropical cyclone over the eastern waters this season.

Extratropical Cyclones--The first half of the month was fairly quiet with only a few cyclones of any significance. This was one of them. On the 2d a multicentered storm moved across Japan. The FERNSIDE was well east of the storm at 1200 but still managed 45-kn gales with 15-ft seas. By the 3d at 1200

it had consolidated into a 978-mb center near 43°N, 165°E. The VOLNA was about 250 mi southwest of the center with 45-kn westerly winds and 23-ft seas. At 0000 on the 4th, the MEDELENA (37°N, 173°E) had 50-kn southerly winds on her starboard side as the front approached. North of the front and 300 mi south of the center, the TACOMA MARU was sailing into 50-kn winds and 20-ft swells.

By 1200 on the 4th, the 964-mb LOW had crossed into the Bering Sea. The DAIKEI MARU near 49°N, 177°E, was headed eastward with 40-kn winds and 33-ft swells on her stern. Far to the west a ship near Mys Lopatka had below freezing northwesterly 50-kn winds. Other ships in the southern quadrant reported 40-kn gales. Twelve hours later the DAIKEI MARU was still riding 20-ft swells. The INDIAN MAIL was not far away at 50°N, 175°W, with 30-ft swells. At 1200 on the 5th, they were 33 ft, and the winds were 45 kn.

On the 6th the LOW started to weaken as it approached the Bering Strait. It became stationary and dissipated on the 8th.

During the second week of the month the ocean was dominated by high pressure. On approximately the 13th, cyclones started making inroads into the high pressure as the centers weakened and drifted southeastward.

Late on the 12th, a frontal wave developed near 27°N, 142°E. It moved eastward rapidly under the zonal flow. On the 14th the KOREAN PEARL was northwest of the center with 52-kn winds as the LOW pressed against an elongated HIGH to the north. The surface LOW came to an abrupt halt on its easterly track late on the 14th when it came under direct influence of an upper-air LOW that formed east of Japan on the 12th. By the 15th the LOWs were vertically stacked and stationary. At 1800 on the 14th, two ships along 35°N and north of the center reported 43- and 48-kn winds from the east. At 0000 on the 15th, the 992-mb Low was near 32°N, 162°E. The ERISORT near 35°N, 157°E, about 300 mi northwest of the center boasted of 50-kn winds. At 0600 they were 60 kn.

The continuing circulation built the swell waves, and at 0000 on the 16th, the HAGOROMO MARU was east of the center and just north of the front with 30-ft swells and 45-kn gales. At this time another LOW was moving northeastward from Japan's southern coast. By the 17th the new cyclone had absorbed the older one.

This was the cyclone that absorbed the one previously described. It had its origin south of Shikoku on the 15th at a frontal occlusion. The center passed south of Tokyo late on the 15th and early on the 16th, and a ship found 26-ft swell waves just off the coast. At 1200 the PESTOVO was near 40°N, 147°E, with 60-kn easterly winds. This Low was centered at 40°N, 147°E, at 988 mb on the 17th at 1200. The CHIKURA MARU (43°N, 154°E) was fighting 40-kn easterly winds and 33-ft southeasterly swells.

A long, narrow high-pressure ridge was blocking both the northerly and easterly movement of the storm as it pushed toward the north along the Kurile Islands. Maximum winds were in the 40-kn range on the 18th. On the 19th the high-pressure ridge defeated the LOW.

This storm was born late on the 15th between two high-pressure cells, a 1036-mb centered off the California coast and a migrant HIGH that broke off the Pacific High and moved northwestward. On the 17th the storm was 998 mb near 43°N, 162°W. The PRESIDENT MADISON was about 300 mi west of the center and measured 36-kn gales and 17-ft seas. Late on the 17th, the 992-mb LOW popped northward between the two HIGHs. At 0600 on the 18th the center was near 53°N, 154°W. The PHILADELPHIA was still further north at 58.5°N, 148.6°W, and was pounded by easterly 60-kn winds, 15-ft seas, and 20-ft swells. By 1200 the pressure had plunged to 977 mb. On the 19th the storm split into two centers, the northern one over the Yukon River in western Alaska and the southern one near Kodiak Island. Later in the day, only the northern center prevailed.

Two weak LOWs over the Gulf of Alaska on the 25th joined forces on the 26th to produce a 995-mb LOW near 52°N, 135°W. The OCEANOGRAPHER was off the Oregon coast at 43°N, 125°W, with 45-kn southerly winds and 12-ft seas. The WEST OCEAN near 48°N, 136°W, had 40-kn winds at 0600 and 45 kn at 1200. The seas were running at 16 ft, but by 1800 they were 20 ft. At 0000 on the 27th, the GALVESTON (50.6°N, 130.8°W) had 45-kn southeasterly winds and 16-ft seas. The YEH YUNG was 180 mi to the south with 26-ft seas and 36-ft swells. On the 28th the LOW evaporated near the Strait of Juan de Fuca.

Tropical Cyclones, Eastern Pacific--Ava became the fifth tropical cyclone to develop during May in the eastern North Pacific since 1966. She was first spotted on the 25th about 100 mi northeast of Clipperton Island. During the course of her life she meandered northward between Clipperton and Socorro Islands. Ava reached tropical storm strength on the 26th, and maximum winds near her center climbed to 55 kn on the 28th after she crossed the 15th parallel near 111°W. She dissipated on the 30th.

Casualties--The AUSTRAL ENSIGN (21,150 tons) arrived at Auckland with heavy weather damage. The 18,250-ton LIBERIAN STATESMAN encountered heavy weather 3 days out of Portland, Ore., enroute to Pusan, during the last week of the month. The vessel put into Seattle for repairs. On the 7th the 3,964-ton BLUE SHIMONOSEKI grounded in fog off Hamina. The 3,321-ton Panamanian KADINA was in Singapore Roads for repairs on the 18th, when she capsized and sank during heavy weather. The crew was saved.

SMOOTH LOG, JUNE 1977--The main features this month were high pressure centers: the Pacific High off the west coast of the United States, a HIGH south of Kamchatka, and another over Saint Matthew Island in the Bering Sea. There were more cyclones than usual, but they were generally small and weak. Their primary path was from slightly south of Japan eastward to near 160°W where they turned northeastward to the Gulf of Alaska. A secondary path extended from the Kuril Islands to the Aleutians to dissipate near the Alaska Peninsula. Although they did not affect shipping, there was a series of storms over eastern Siberia, west of the Bering Strait.

The monthly normal sea-level pressure pattern did not differ greatly from climatology. There were two principal low-pressure centers: one south of the Rat Islands at 1011 mb and another over southwestern Alaska at 1013 mb. These were 1 and 2 mb higher, respectively, than their climatological counterparts. There was an anomalous 1015-mb HIGH between and slightly north of the two LOWs. The Pacific High at 1025 mb was near 38°N, 137°W, 1 mb higher in pressure than its climatological mate which is normally at 34°N, 145°W. The other high-pressure center was 1016 mb near 43°N, 162°E.

There were many weak anomaly centers. The highest in pressure was plus 4 mb south of Kamchatka in conjunction with the high-pressure center. A small, positive 3-mb center was over the Bering Sea with that high-pressure center, and an elongated positive 3-mb area paralleled the west coast of the United States. The largest negative area (minus 3 mb) covered a relatively large area between Hawaii and Alaska.

In the upper air the 700-mb heights averaged higher than climatology with the exception of over the Gulf of Alaska and into the Mackenzie Mountains. The pressure centers were shifted westward, especially the HIGH along latitude 30°N, but the troughs and ridges along the coasts remained normally located.

Tropical storm Ruth moved northward out of the South China Sea through the Formosa Strait in the middle of the month. Over the Eastern North Pacific tropical storm Bernice formed during the last week.

Extratropical Cyclones--Happily for mariners this was a quiet month over the North Pacific. There were many small LOWs and frontal waves, but only a few developed into major storms.

One of the more severe storms originated over the central ocean as a frontal wave on the first day of the month along 30°N. It was a maverick from the start. On the 2d it turned northward and then northwestward before taking an almost due north track until the 6th. Its direction was controlled by an upper air cutoff LOW with HIGHs to the north and east blocking its movement. At 0000 on the 3d, the LOW was 998 mb near 35°N, 172°E. The ARNOLD MAERSK (37°N, 176°E) had 50-kn winds and 26-ft seas out of the east. The JRDT was less than 60 mi northeast of the center with 16-ft seas and 26-ft swells. At 1200 she moved northwest of the center with 20-ft seas and 26-ft swells. The TAISAN MARU, north of the center near latitude 40°, had 35-kn easterly winds and 16-ft seas. At 0000 on the 4th, the LOW was on its northerly track at 993 mb. The JAPAN RAINBOW was in the southwest quadrant at 30°N, 166°E, with 60-kn northwesterly winds and 13-ft waves. There were several reports of 35-kn winds and 16-ft waves north of the center.

By the 5th the upper air LOW had deteriorated to a trough, and the northern high-pressure center had moved southeastward to join with the stronger eastern HIGH. The surface storm was weakening as it lost upper air support. The LAUREL was east of the center with 35-kn winds. At 1200 on the 6th, the storm took a sharp turn eastward as it moved around the upper air ridge. On the 8th it again turned northward to die over the Bering Sea on the 10th.

On the 8th the 1032-mb Pacific High was pressing against the U.S. West Coast. A 1002-mb thermal LOW was stationary over the Gulf of California. The pressure of the HIGH increased and the LOW decreased tightening the gradient. At 1800 the ORIENTAL EDUCATOR was southwest of San Francisco with 62-kn winds and 20-ft waves. The KLHZ was headed northwestward out of San Francisco at 0000 on the 9th with 36-kn winds and 15-ft seas. At 1200 the winds were 39 kn and the seas 20 ft off Cape Mendocino. A SHIP off Cape Blanco had 50-kn winds. At 0600 on the 10th, the ENDEAVOR off Cape Disappointment reported 76-kn winds. The isobars were piled up on the west side of the coastal mountains. On the 11th the gradient relaxed as both pressure centers weakened.

This was another storm born on a frontal wave. It began on the 11th near 34°N, 155°E, and traveled eastward. By 0000 on the 13th, the LOW was 998 mb near 40°N, 179°W. The POST CHALLENGER (36°N, 179°E) in the warm sector south of the LOW had 45-kn winds. This LOW was catching up with another LOW to its north and turned northwestward on the 14th to absorb it. The PRESIDENT MADISON (50°N, 169°W) was north of the center at 0000 with 40-kn winds and 18-ft seas. At 1200 the LOW was 986 mb, one of the deeper LOWs of the month. Minimal gale-force winds were reported around the storm. On the 15th the storm again turned eastward and was absorbed by another LOW on the 17th.

This storm formed off Hokkaido on the 13th. It was 1000 mb near 42°N, 150°E, at 1200 on the 14th. The ZINYUU MARU was southwest of the center with 40-kn winds. On the 15th other ships were reporting 35- to 40-kn winds in the vicinity of the storm. At 0600 on the 16th, the FEDSTEEL was in the southeast quadrant with 42-kn southwesterly winds. The seas were 10 ft. The 994-mb storm was near 46°N, 167°E. The storm continued to move eastward, but it was weakening rapidly and disappeared on the 19th.

A front had lain across southern Japan since the 15th. Waves were rippling along the front bringing rain to most of the islands. Downpours lashed Kyushu on the 15th and 16th causing floods and landslides. At least 1,400 homes were flooded. Up to 11 in of rain were reported with several locations reporting about 7 in. Trains were cancelled as the tracks were inundated. Earlier on the 10th the area had received heavy rains of up to 5 in with flooding and landslides. On the 18th an unstable wave was analyzed over southern Kyushu. It developed into a closed circulation as it moved eastward. The EMMA OLDENDORFF reported 37-kn winds near the center with rain showers. The MONTANA was southwest of the storm with 35-kn gales at 0600 on the 19th. At 1200 the ASIA GOLD (34°N, 150°E) was 5° longitude east of the storm with 42-kn winds. The PACIFIC WING was about 100 mi east of the center at 0000 on the 20th with thunderstorms and seas of 18 ft.

The storm continued moving east-northeastward under zonal west-to-east upper air flow with mainly breeze-force winds. On the 22d it turned more northeastward and started to deepen. The PRESIDENT TAFT was over 600 mi northeast of the center with 35-kn winds and 13-ft waves. At 1800 the JAMAICA MARU was hit by 40-kn winds and 6 hr later had 48-

kn with 18-ft waves at 44.7°N, 160.1°W. The LOW was 986 mb near 45°N, 157°W. The ARNOLD MAEPSK (43°N, 150°W) radioed 40-kn winds and 20-ft seas at 0600 on the 23d. At 1800 the WVFX (44.5°N, 149.7°W) was sailing into 42-kn winds, 20-ft seas, and 26-ft swells. The LOW now was in the Gulf of Alaska and dissipating rapidly.

This storm generated on the same frontal system and in basically the same air mass as the previous storm. Many minor waves had developed and dissipated on the front as it wandered south of Kyushu. This wave was first analyzed late on the 19th. On the 22d the storm was near 39°N, 159°E, at 1000 mb, when a ship reported 16-ft swells south of the center. At 1200 a ship northwest of the center had 40-kn gales. At 0000 on the 23d, there was a rash of 35- to 40-kn winds south and west of the 1000-mb storm. The highest waves were 20 ft. Forty-knot winds and 20-ft waves were also observed on the 24th.

The storm was 987 mb near 45°N, 156°W, at 0000 on the 25th. The JAPAN BEAR was about 180 mi south of the center with 26-ft seas and swells. Gale reports continued through the day. On the 26th there was one report of 37 kn south of the storm, but late that day it no longer existed.

The same front that separates Polar and Tropic air and generated the two previous storms also spawned this one. This frontal wave formed in midocean southwest of the previous storm late on the 24th. At 0600 on the 26th, a ship east of the center had southerly gales. At 1800 that day and at 0000 on the 27th, the PACIFIC ARROW reported 40-kn gale-force winds and seas to 16 ft near 44°N, 156°W. At 0000 the YAMASHIN MARU (45°N, 155°W) had westerly 47-kn winds and 26-ft waves. The BEISHU MARU was surprised by 54-kn winds from the south about 300 mi east of the center at 0600. Late on the 28th, the LOW moved inland over Queen Charlotte Island. The WESTWARD VENTURE, which recently joined the West Coast fleet, added her contribution to the greatly valued marine weather observations.

Some kind of record must have been set by this continuous frontal boundary across the North Pacific. It had wandered between 30° and 45°N since about the 12th without a break except near the North American coast as the LOWs dissipated. This wave formed on the front on the 28th near 36°N, 160°E. The storm developed rapidly, and it was 995 mb near 38°N, 170°E, at 1200 on the 29th. The OHTSUKAWA MARU was about 120 mi northwest of the center with heavy rain, 45-kn winds, and 18-ft waves. On the 30th there were several reports of gale-force winds around the storm, especially in the eastern quadrant. The highest waves were 20-ft swells. Late on the 30th and on July 1 and 2, the LOW stalled near 42°N, 175°E, as it became nearly vertically alined with the upper air LOW. On the 2d a ship reported 20-ft seas. On the 3d and 4th the LOW drifted in the same area and filled.

Tropical Cyclones, Eastern Pacific--The tropical depression that was soon to become tropical storm Bernice was found on the 25th languishing near 13°N, 109°W. Traveling west-northwestward, the system was named on the 26th as winds climbed above 35 kn. However, conditions were not favorable for further intensification (fig. 58), and Bernice remained a minimal tropical storm throughout her brief life which ended near 19°N, 120°W, on the 28th.

Tropical Cyclones, Western Pacific--After more than 2 mo of inactivity, the South China Sea spawned tropical storm Ruth. She formed on the 14th about 300 mi west of Manila. Heading northward, she intensified. Winds near her center reached a peak of about 60 kn on the 15th near 20°N, 117°E. Ruth turned toward the north-northeast and moved across the Formosa Strait, brushing the coast of mainland China on the 16th. She then turned northeastward but lost strength and dissipated in the East China Sea.

Casualties--The first weekend of June was bad for low visibility around Japan. Early on the 5th, the 999-ton MIKI MARU and the 3,854-ton Panamanian SINAN SARI collided off Cape Trako in fog. That night the 496-ton TOYO MARU and the Soviet passenger ship FELIKS DZERZHINSKIY scraped each other off Cape Kinkayan in fog. There were no injuries in either case. On the 10th, the 669-ton liquefied gas carrier EISHIN MARU No. 2 and the 9,053-ton OCEAN HAPPINESS collided in fog off Matusyama. The EISHIN MARU was holed and towed to Washigasu Bay where she was awash. The crew had previously abandoned the ship. On the 30th, the 1,131-ton LPG carrier TAIWA MARU and the 12,690-ton Panamanian freighter CHUENOMON collided in fog on the Inland Sea.

The South Pacific also has its share of casualties owing to bad weather. The Liberian VILLANGER had cargo shifted in the Gulf of Penas on the Chilean coast on the 21st and arrived Puerto Montt with an 8-degree list and foredeck damage.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

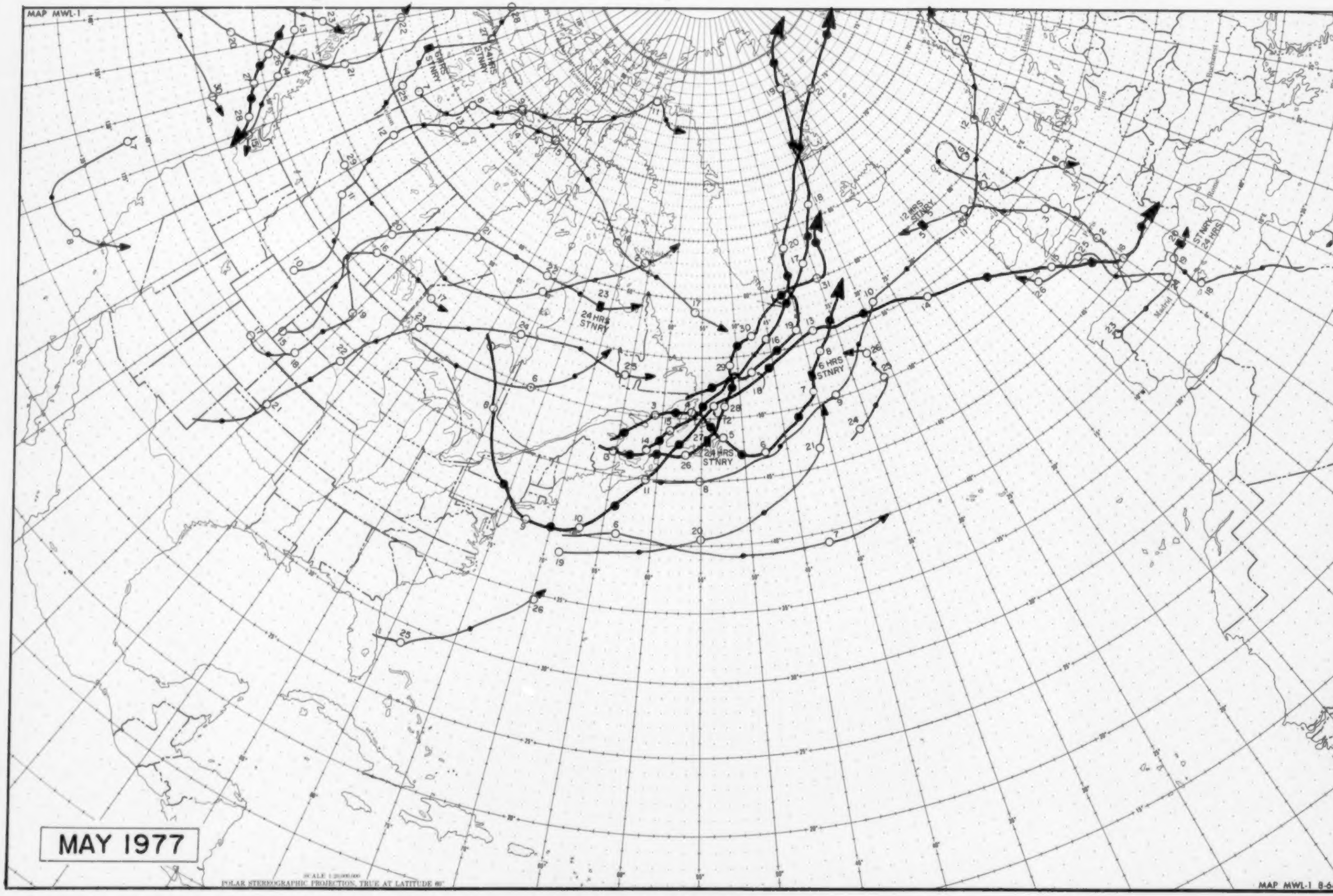


Figure 44.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

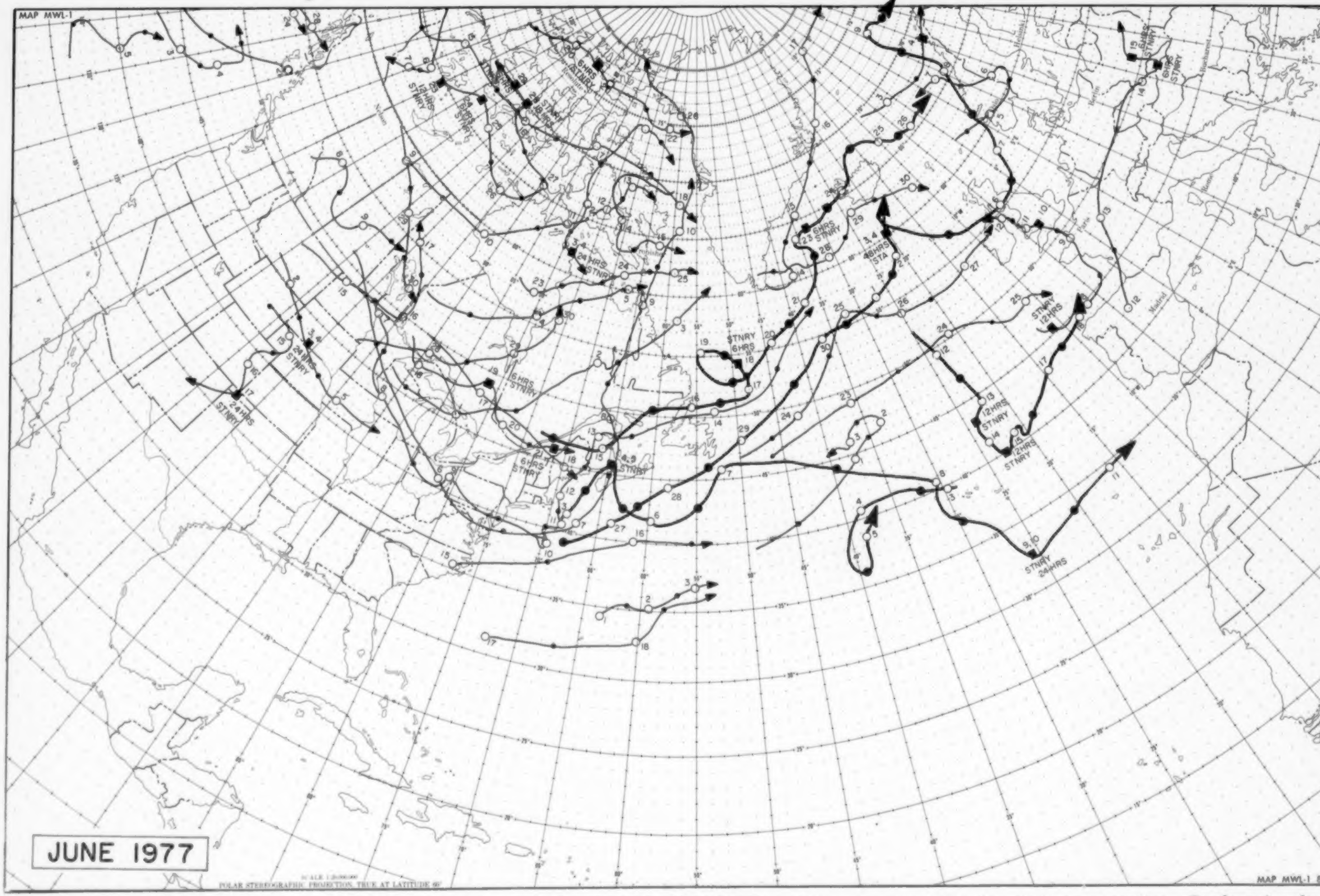


Figure 45.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

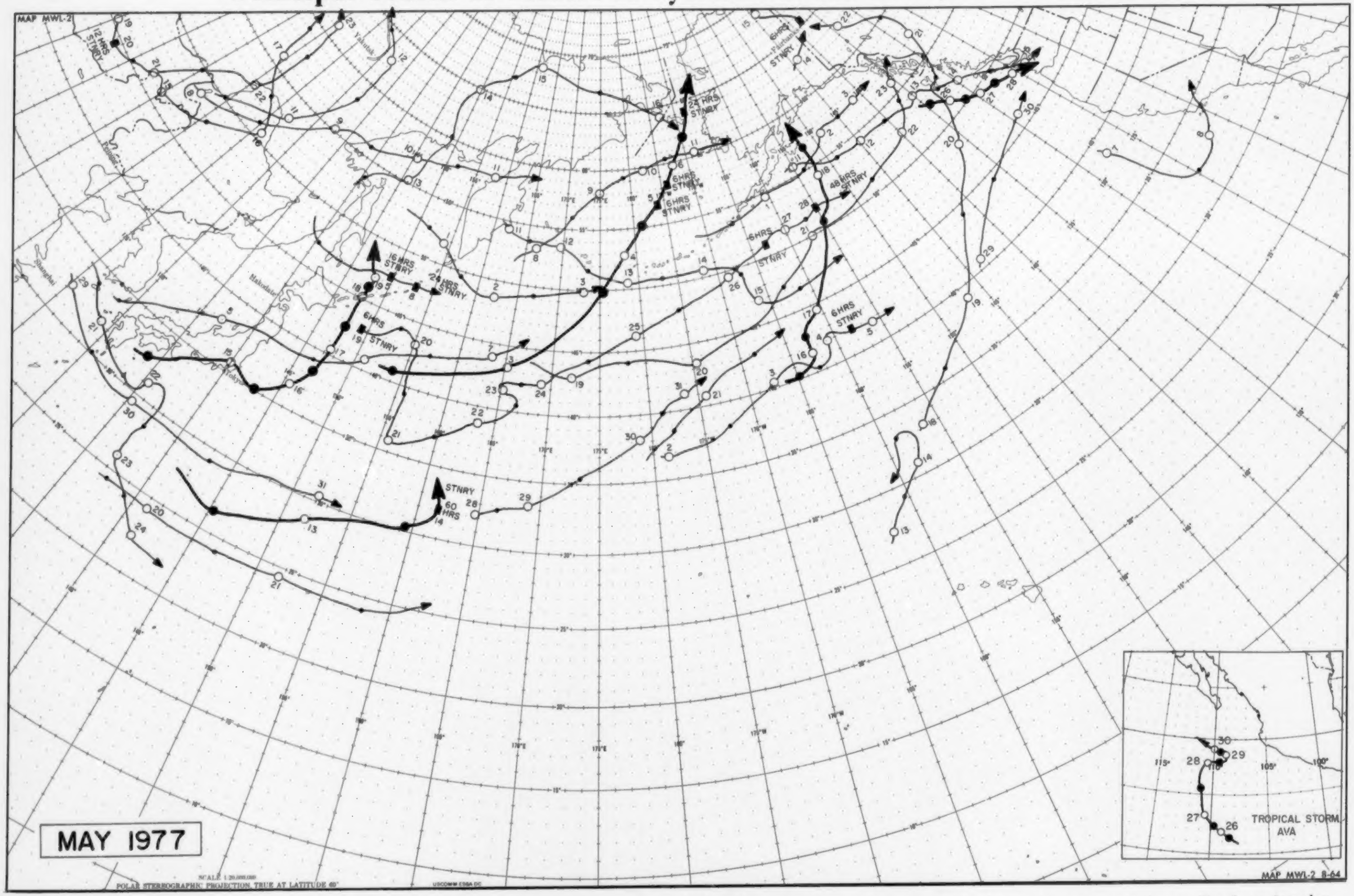


Figure 46.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

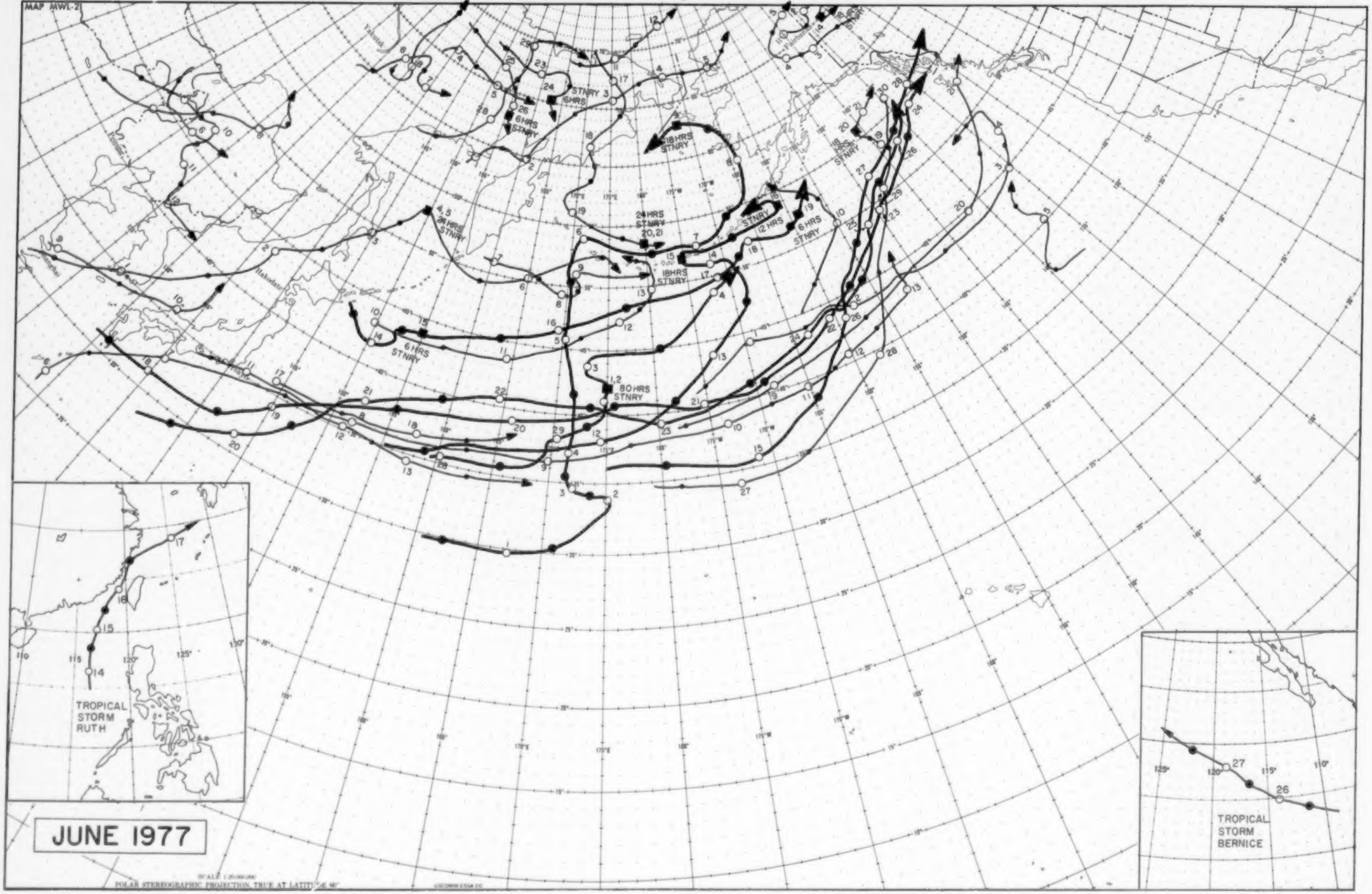


Figure 47.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 7
U. S. Ocean Buoy Climatological Data
May and June 1977

MAY — DATA SUMMARY — E801
AVERAGE LATITUDE 35.0N — AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	13.6	(10 09)	20.0	23.8	(07 18)	235	30
SEA TEMP (DEG C)	17.2	(26 08)	22.0	24.0	(04 21)	235	30
AIR-SEA TEMP (DEG C)	-07.1	(10 12)	01.1	06.2	(28 18)	235	30
PRESSURE (MBAR)	0987.3	(09 12)	1015.0	1028.3	(01 15)	235	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 235

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	3.4	2.8				6.4	10.7
NE	1.7	3.4	5.1				10.2	10.0
E	.8	3.4	7.2	.4			11.0	12.8
SE	.8	1.7	6.0				8.4	12.5
S	.8	5.5	7.2				13.6	10.5
SW	.4	1.7	14.0	3.0	.4		18.8	16.8
W		3.0	8.5	4.3			15.7	17.3
NW		1.7	5.1	4.3			11.1	18.2
CALM	2.1						2.1	.0
TOTAL	7.2	23.0	56.6	11.9	.4		100.0	14.0

MAX WIND — SPEED: 34 KNOTS; DIRECTION: 230 DEG; DAY: 08; HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 235

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	2.6	81.3	12.3	2.1	1.7				1.4M	4.5M (10 12)

JUNE — DATA SUMMARY — E801
AVERAGE LATITUDE 35.0N — AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	17.2	(25 18)	23.5	26.0	(20 21)	155	30
SEA TEMP (DEG C)	20.8	(10 08)	24.0	27.3	(29 00)	155	30
AIR-SEA TEMP (DEG C)	-08.6	(25 18)	-00.5	01.6	(26 12)	155	30
PRESSURE (MBAR)	1008.5	(10 12)	1014.5	1021.1	(23 15)	123	22

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 107

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		5.6	.8				6.5	7.4
NE		1.8		.8			2.8	13.7
E		2.8	4.7				7.5	12.0
SE		.8	6.5				7.5	14.3
S	.8	5.6	5.6	1.8			14.0	12.5
SW		4.7	15.0	5.6			25.2	16.2
W		7.5	10.3	1.8			19.6	15.1
NW		9.3	6.5				15.9	10.2
CALM								
TOTAL	.8	38.3	50.5	10.3			100.0	13.0

MAX WIND — SPEED: 28 KNOTS; DIRECTION: 220 DEG; DAY: 07; HOUR: 00

MAY — DATA SUMMARY — E803
AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 147.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	02.1	(01 12)	04.8	07.5	(31 08)	248	31
SEA TEMP (DEG C)	04.3	(02 12)	05.3	07.3	(31 08)	248	31
AIR-SEA TEMP (DEG C)	-02.5	(24 12)	-00.5	01.6	(18 08)	248	31
PRESSURE (MBAR)	0981.8	(02 08)	1010.0	1028.1	(15 18)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 245

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	4.8	1.2				6.5	7.8
NE	.8	1.6	1.6				4.1	10.1
E	.8	4.0	3.7	.4			8.8	10.7
SE		4.8	6.9	4.9			16.7	16.0
S	.8	4.1	12.2	.8			18.0	13.6
SW	.4	2.4	7.3	.8			11.0	13.4
W		3.3	21.2				24.5	14.5
NW	.4	6.1	2.0				8.6	8.5
CALM	.8						.8	.0
TOTAL	4.5	32.2	56.3	6.9			100.0	12.8

MAX WIND — SPEED: 30 KNOTS; DIRECTION: 140 DEG; DAY: 18; HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	.8	55.5	34.0	8.7					1.7M	5.5M (18 15)

JUNE — DATA SUMMARY — E803
AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 147.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	06.4	(04 12)	08.5	11.1	(27 00)	238	30
SEA TEMP (DEG C)	06.9	(01 15)	08.6	10.8	(27 03)	237	30
AIR-SEA TEMP (DEG C)	-01.6	(20 15)	-00.1	00.8	(30 21)	237	30
PRESSURE (MBAR)	0998.8	(20 18)	1013.0	1022.7	(08 00)	238	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 237

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.3	2.5	7.2				11.0	11.5
NE	1.3	3.0	8.3	.4			13.9	11.8
E	.4	4.2	5.5	1.7			11.8	13.6
SE	.8	5.9	5.1	.8			12.7	10.8
S	1.7	5.9	12.2				19.8	11.1
SW	1.7	5.1	3.0				9.7	8.3
W	.8	5.5	3.0				9.3	8.8
NW	.8	6.3	3.8				11.0	9.3
CALM	.8						.8	.0
TOTAL	8.7	38.4	48.8	3.0			100.0	10.7

MAX WIND — SPEED: 30 KNOTS; DIRECTION: 100 DEG; DAY: 16; HOUR: 03

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 238

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	3.4	82.8	12.6	1.3					1.3M	3.0M (16 09)

MAY — DATA SUMMARY — E804
AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	22.8	(24 21)	25.0	27.1	(28 21)	104	13
SEA TEMP (DEG C)	25.0	(22 15)	25.7	27.4	(28 21)	104	13
AIR-SEA TEMP (DEG C)	-03.0	(24 21)	-00.7	00.1	(31 15)	104	13
PRESSURE (MBAR)	1008.8	(28 00)	1015.0	1018.2	(18 18)	104	13

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 104

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.0	8.7	1.9				12.5	7.2
NE	1.0	9.6	1.0				11.5	5.8
E	1.0	14.4	30.8				46.2	11.6
SE	1.0	2.9	1.9				5.8	8.2
S	1.0	1.9					3.8	3.0
SW	1.0	1.0					1.9	3.5
W	1.0	6.7					8.7	5.3
NW		7.7					7.7	5.4
CALM	1.9						1.9	.0
TOTAL	11.5	52.9	35.6				100.0	8.9

MAX WIND — SPEED: 18 KNOTS; DIRECTION: 110 DEG; DAY: 21; HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 70

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	41.4	20.0	38.6						1.2M	2.5M (23 00)

JUNE — DATA SUMMARY — E804
AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	25.5	(07 00)	27.2	28.6	(30 21)	238	30
SEA TEMP (DEG C)	26.0	(08 00)	27.5	29.0	(30 21)	237	30
AIR-SEA TEMP (DEG C)	-01.3	(08 03)	-00.4	00.2	(14 15)	237	30
PRESSURE (MBAR)	1010.2	(08 00)	1017.2	1021.9	(23 18)	238	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 238

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.7	4.6	.4				6.7	5.5
NE	.8	4.2	3.4				8.4	8.2
E	2.5	17.2	13.9				33.6	8.8
SE	1.3	18.5	20.2				39.9	10.3
S		1.7	1.7				3.4	10.5
SW		2.1					2.1	7.8
W	.4	.8	2.1				3.4	8.0
NW	.4	1.7					2.1	4.6
CALM	.4						.4	.0
TOTAL	7.8	50.8	41.6				100.0	9.3

MAX WIND — SPEED: 20 KNOTS; DIRECTION: 080 DEG; DAY: 04; HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 215

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	51.6	48.4							.9M	1.5M (14 12)

MAY — DATA SUMMARY — E815
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	18.2	(11 08)	21.8	24.2	(30 21)	248	31
SEA TEMP (DEG C)	21.7	(03 00)	23.2	25.3	(31 21)	247	31
AIR-SEA TEMP (DEG C)	-05.8	(11 08)	-01.6	00.4	(14 15)	247	31
PRESSURE (MBAR)	1001.8	(08 12)	1016.8	1027.2	(01 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 248

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		4.0	4.8				8.8	12.2
NE	.4	4.0	2.0				6.5	9.3
E		4.4	6.0	2.0			12.5	13.4
SE	.8	1.6	8.5	1.2			12.1	14.0
S	.8	10.8	3.2				14.8	8.1
SW	1.6	8.0	14.5	.4			22.5	12.1
W	.4	4.8	12.1				17.3	12.0
NW	.4	2.8	1.6				4.8	8.3
CALM	.4						.4	.0
TOTAL	4.8	38.7	52.8	3.6			100.0	11.8

MAX WIND — SPEED: 24 KNOTS; DIRECTION: 100 DEG; DAY: 23; HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	17.7	71.8	10.5						1.1M	2.9M (25 15)

JUNE — DATA SUMMARY — E815
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	20.5	(10 06)	24.0	27.0	(30 21)	240	30
SEA TEMP (DEG C)	23.8	(13 08)	25.0	27.6	(30 21)	240	30
AIR-SEA TEMP (DEG C)	-04.8	(27 15)	-00.8	00.7	(08 21)	240	30
PRESSURE (MBAR)	0998.6	(07 08)	1014.8	1021.8	(04 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 240

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.8	2.1	2.9				5.8	10.8
NE	.4	.4	1.7				2.5	18.7
E		2.1	1.7				3.8	10.1
SE	.4	2.1	.8				3.3	8.3
S	1.7	7.1	5.4	.8			15.0	10.7
SW	.4	6.7	35.0	4.2			46.3	15.3
W	.4	7.1	8.8	.4			16.7	11.7
NW	.4	1.3	3.3				5.0	13.1
CALM	1.7						1.7	.0
TOTAL	6.3	28.8	59.6	5.4			100.0	12.8

MAX WIND — SPEED: 28 KNOTS; DIRECTION: 230 DEG; DAY: 08; HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	14.6	77.8	7.5						1.1M	2.5M (10 18)

MAY — DATA SUMMARY — E816
AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
PRESSURE (MBAR)	1002.2	(25 15)	1017.6	1027.6	(15 18)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 247

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		5.3	6.9	1.6			13.8	13.1
NE		3.8	2.4				6.1	9.4
E	.4	2.0	.8				3.2	8.2
SE		2.4	.4				2.8	7.8
S	.8	4.5	4.5	.8			10.5	10.7
SW	.8	2.0	5.3	.8			8.9	12.8
W	.4	5.7	13.0	2.0			21.1	13.8
NW	1.2	5.3	21.5	5.7			33.6	16.1
CALM								
TOTAL	3.6	30.8	54.7	10.9			100.0	13.4

MAX WIND — SPEED: 28 KNOTS; DIRECTION: 320 DEG; DAY: 05; HOUR: 16

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		46.0	32.7	16.1	5.2				2.1M	6.0M (27 12)

JUNE — DATA SUMMARY — E816
AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
PRESSURE (MBAR)	1005.8	(03 15)	1016.8	1025.5	(02 06)	47	6

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 47

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N								
NE								
E			2.1				2.1	11.1
SE			2.1				2.1	11.0
S		8.5	25.5	4.3			38.3	14.2
SW		2.1	19.1				21.3	14.5
W		10.6	25.5				36.2	11.4
NW								
CALM								
TOTAL		21.3	74.5	4.3			100.0	13.1

MAX WIND — SPEED: 27 KNOTS; DIRECTION: 180 DEG; DAY: 03; HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 47

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		74.5	25.5						1.6M	2.5M (03 21)

MAY

DATA SUMMARY

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 148.0W E817

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.0	(01 03)	03.8	07.2	(31 21)	244	31
SEA TEMP (DEG C)	03.1	(02 00)	04.5	08.0	(31 21)	240	31
AIR-SEA TEMP (DEG C)	-02.9	(20 03)	-00.7	01.2	(31 21)	240	31
PRESSURE (MBAR)	0985.1	(03 18)	1011.8	1030.4	(07 21)	244	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		.4	.4				.8	11.5
NE		.4	.4				.8	8.5
E		4.1	4.8				8.9	10.5
SE		2.8	3.3	.4			6.5	13.4
S	.4	4.1	5.3	.8			10.6	12.2
SW		5.3	12.6	2.8			20.7	15.5
W	.8	4.5	23.2	15.8			44.3	18.8
NW	.8	2.0	2.8	.4			6.1	10.7
CALM	1.2						1.2	.0
TOTAL	3.3	23.6	52.8	20.3			100.0	15.5

NO. OF OBS: 246

MAX WIND
SPEED: 32 KNOTS
DIRECTION: 280 DEG
DAY: 18
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		40.0	28.3	17.8	4.8				2.0M	5.0M (02 00)

JUNE

DATA SUMMARY

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 150.0W E817

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	04.6	(02 12)	07.3	08.8	(30 21)	240	30
SEA TEMP (DEG C)	05.0	(08 03)	07.5	08.5	(28 03)	238	30
AIR-SEA TEMP (DEG C)	-02.1	(22 15)	-00.3	01.0	(19 03)	238	30
PRESSURE (MBAR)	0987.8	(15 12)	1012.9	1020.7	(30 21)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.7	4.6				6.3	12.2
NE		1.7	4.6				6.3	12.7
E	1.7	4.6	5.4	2.1			13.8	12.6
SE	.8	2.5	2.1	.8			6.3	11.3
S	.8	6.7	5.8	1.3			14.6	10.8
SW	.8	4.6	5.4				10.8	10.2
W	.4	14.2	14.2				28.8	10.5
NW	.8	6.7	5.0				12.5	9.8
CALM	.8						.8	.0
TOTAL	6.3	42.5	47.1	4.2			100.0	10.8

NO. OF OBS: 240

MAX WIND
SPEED: 25 KNOTS
DIRECTION: 100 DEG
DAY: 10
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	4.2	77.5	18.3						1.3M	2.5M (24 03)

MAY

DATA SUMMARY

AVERAGE LATITUDE 51.0N AVERAGE LONGITUDE 136.0W E819

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
PRESSURE (MBAR)	0988.2	(28 12)	1013.4	1031.2	(18 00)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			4.0	1.6			5.6	10.7
NE		.4					.4	5.0
E	.8	.8	4.4				6.0	12.0
SE		3.6	7.3	1.2			12.1	13.4
S	.8	2.0	4.4	3.6			10.8	15.0
SW	.4	2.0	7.3	2.0			11.7	16.0
W	1.6	3.6	12.1	10.1			27.4	17.7
NW		3.2	18.0	3.2			25.4	16.4
CALM	.4						.4	.0
TOTAL	4.0	15.7	58.5	21.8			100.0	16.1

NO. OF OBS: 248

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 280 DEG
DAY: 28
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		33.8	38.3	22.6	5.2				2.2M	4.5M (27 18)

JUNE

DATA SUMMARY

AVERAGE LATITUDE 51.0N AVERAGE LONGITUDE 136.0W E818

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.5	(20 00)	09.0	11.4	(30 00)	120	17
SEA TEMP (DEG C)	08.5	(30 21)	10.0	10.7	(23 00)	120	17
AIR-SEA TEMP (DEG C)	-01.8	(20 00)	-00.1	01.8	(30 00)	120	17
PRESSURE (MBAR)	1001.5	(24 12)	1018.4	1028.6	(20 00)	234	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N			2.1				2.1	10.0
NE			2.1				2.1	17.0
E		2.1	2.6				4.7	10.0
SE	.4	.4	2.6	1.7			5.1	10.0
S		4.3	12.0	3.8			20.1	16.1
SW	1.3	4.3	10.7	7.7			23.8	16.7
W		4.7	20.1	1.7			26.5	14.4
NW		3.4	12.0				15.4	12.8
CALM								
TOTAL	1.7	19.2	64.1	15.0			100.0	15.3

NO. OF OBS: 234

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 220 DEG
DAY: 30
HOUR: 21

MAY

DATA SUMMARY

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W E820

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.7	(11 03)	11.3	14.0	(20 03)	247	31
PRESSURE (MBAR)	1007.1	(25 03)	1022.4	1036.5	(15 21)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		8.1	7.7				15.7	10.8
NE	.4	1.2	3.2				4.8	10.8
E		1.6					1.6	8.0
SE		1.2	.4				1.6	10.3
S	.4	1.2	2.4	.4			4.4	14.4
SW		2.0	7.3	1.6			10.8	15.1
W		3.6	24.2	5.2			33.1	16.7
NW	.4	3.2	21.0	2.8			27.4	15.0
CALM	.4						.4	.0
TOTAL	1.6	22.2	66.1	10.1			100.0	14.7

NO. OF OBS: 240

MAX WIND
SPEED: 26 KNOTS
DIRECTION: 270 DEG
DAY: 20
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	2.0	48.2	38.3	10.5					1.8M	3.5M (04 03)

JUNE

DATA SUMMARY

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W E820

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	10.0	(10 00)	13.6	17.5	(28 00)	233	30
PRESSURE (MBAR)	1005.4	(03 15)	1024.5	1034.1	(28 21)	233	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	4.3	4.3				9.0	8.8
NE		11.2	8.6				19.7	10.5
E	.4	2.6	4.7				7.7	10.8
SE	.4	1.3	3.8				5.6	11.3
S		1.3	8.6	1.7			11.6	17.2
SW	.4	2.1	12.0	.4			15.0	15.6
W	2.1	9.4	10.3	1.3			23.2	11.6
NW	.9	3.0	3.0				6.9	10.7
CALM	.4						.4	.0
TOTAL	5.2	35.2	56.2	3.4			100.0	12.3

NO. OF OBS: 233

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 100 DEG
DAY: 02
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 233

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	3.0	68.5	23.6	3.4	.4				1.5M	4.0M (24 12)

MAY

DATA SUMMARY

AVERAGE LATITUDE 42.1N AVERAGE LONGITUDE 072.0W E834

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	04.6	(08 15)	12.1	18.4	(28 21)	241	31
SEA TEMP (DEG C)	07.2	(11 00)	11.1	17.3	(28 18)	240	31
AIR-SEA TEMP (DEG C)	-05.0	(08 15)	00.8	08.2	(18 03)	238	31
PRESSURE (MBAR)	0988.5	(10 06)	1017.1	1030.5	(01 15)	238	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.7	.8	.4			3.4	11.3
NE	1.5	7.1	3.4				11.8	8.7
E	.4	1.3	.4				2.1	6.8
SE	1.3	2.1	.4				3.8	4.9
S	2.8	12.6	2.5				18.1	7.1
SW	1.3	21.4	12.2	.4			35.3	8.6
W	.4	12.6	2.5				15.5	7.8
NW	.4	6.3	.8	2.1			9.7	12.3
CALM	.4						.4	.0
TOTAL	8.8	65.1	23.1	2.9			100.0	8.8

NO. OF OBS: 238

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 310 DEG
DAY: 10
HOUR: 06

JUNE

DATA SUMMARY

AVERAGE LATITUDE 40.1N AVERAGE LONGITUDE 073.0W E834

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	11.6	(10 15)	16.7	22.3	(30 21)	238	30
SEA TEMP (DEG C)	11.8	(11 06)	16.0	20.8	(26 21)	238	30
AIR-SEA TEMP (DEG C)	-01.7	(10 15)	00.7	03.4	(05 21)	238	30
PRESSURE (MBAR)	0995.4	(07 06)	1012.2	1022.7	(14 12)	237	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		5.1	3.0	2.1			10.1	14.1
NE	.8	3.0	2.1				5.9	9.1
E	2.1	5.1	.4				7.6	5.7
SE	.8	3.8	2.5				7.2	8.6
S	.8	11.0	12.2				24.0	10.1
SW	.4	16.0	8.4				24.9	9.7
W	1.3	5.5	2.5				9.3	8.0
NW	.4	3.4	6.3				10.1	11.3
CALM								
TOTAL	6.8	53.6	37.6	2.1			100.0	9.6

NO. OF OBS: 237

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 200 DEG
DAY: 10
HOUR: 21

MAY

DATA SUMMARY

AVERAGE LATITUDE 60.0N AVERAGE LONGITUDE 149.0W E843

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	02.2	(01 00)	06.8	11.1	(18 03)	187	31
SEA TEMP (DEG C)	06.0	(01 12)	08.0	10.5	(17 03)	183	31
AIR-SEA TEMP (DEG C)	-03.8	(01 00)	-01.2	03.2	(18 03)	181	31
PRESSURE (MBAR)	0981.6	(03 00)	1015.2	1028.2	(18 00)	181	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.7						1.7	2.7
NE	2.8	2.2					5.0	3.7
E	2.2	11.1	10.0	8.3			31.7	14.2
SE	1.1	5.0	1.7				7.8	7.8
S	1.7	2.2					3.9	5.2
SW	1.7	4.4					6.1	5.9
W	3.9	21.1	8.9				33.9	8.3
NW	3.9	4.4	.6				8.9	5.7
CALM	1.1						1.1	.0
TOTAL	20.0	50.6	21.1	8.3			100.0	8.2

NO. OF OBS: 180

MAX WIND
SPEED: 28 KNOTS
DIRECTION: 090 DEG
DAY: 01
HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 157

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	22.3	57.3	11.5	8.8					1.3M	3.0M (02 15)

JUNE

DATA SUMMARY

AVERAGE LATITUDE 60.0N AVERAGE LONGITUDE 142.0W E843

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.1	(03 00)	10.2	13.7	(28 03)	113	18
SEA TEMP (DEG C)	08.2	(04 12)	11.2	13.8	(30 21)	110	18
AIR-SEA TEMP (DEG C)	-03.2	(03 00)	-00.8	00.3	(09 03)	110	18
PRESSURE (MBAR)	1005.7	(24 00)	1018.0	1025.3	(10 00)	111	18

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.8	.9					2.7	2.0
NE	3.6	1.8					5.5	2.7
E	2.7	22.7	8.2	.9			34.5	8.2
SE	.8	2.7					3.6	3.8
S	3.6	.9					4.5	3.5
SW		1.8					1.8	6.5
W	.9	30.0	6.4				37.3	8.2
NW	2.7	6.4	.9				10.0	6.0
CALM								
TOTAL	16.4	67.3	15.5	.9			100.0	7.5

NO. OF OBS: 110

MAX WIND
SPEED: 22 KNOTS
DIRECTION: 070 DEG
DAY: 06
HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 101

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	29.7	64.4	5.9						1.0M	2.0M (28 12)

MAY

DATA SUMMARY — E863

AVERAGE LATITUDE 40.8N — AVERAGE LONGITUDE 060.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	05.2	(10 21)	09.4	13.2	(31 18)	225	31
SEA TEMP (DEG C)	06.8	(02 09)	08.1	10.0	(31 18)	225	31
AIR-SEA TEMP (DEG C)	-02.6	(10 21)	01.3	03.7	(29 03)	224	31
PRESSURE (MBAR)	0989.0	(10 06)	1015.0	1029.1	(01 18)	223	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 221

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.9	3.2	1.4				5.4	8.1
NE	1.4	2.3	.9				4.5	6.3
E	.5	1.4	2.3	.5			4.5	10.6
SE	.5	.9	.5				1.8	8.5
S	1.4	2.3	.8				4.5	6.4
SW	1.8	18.1	12.2				32.1	8.2
W	2.7	17.6	20.4	1.4			42.1	10.8
NW	.9	1.8	.9				3.6	6.6
CALM	1.4						1.4	.0
TOTAL	11.3	47.5	38.4	1.8			100.0	9.4

MAX WIND
SPEED: 28 KNOTS
DIRECTION: 280 DEG
DAY: 10
HOUR: 21

MAY

DATA SUMMARY — E871

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 083.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	20.6	(10 06)	24.4	27.0	(28 00)	238	31
SEA TEMP (DEG C)	22.9	(01 12)	24.9	28.3	(26 21)	238	31
AIR-SEA TEMP (DEG C)	-04.0	(10 08)	-00.5	00.5	(01 18)	238	31
PRESSURE (MBAR)	1007.3	(10 08)	1014.1	1018.8	(13 18)	238	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 237

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.3	2.1				3.8	10.4
NE		3.0	8.0				11.0	12.0
E	1.3	14.8	32.5				48.5	12.1
SE	.4	7.2	21.1				28.7	12.5
S		5.1	.4				5.5	7.3
SW		.4					.4	6.0
W	.8	.4					1.3	3.4
NW	.4	.4					.8	3.0
CALM								
TOTAL	3.4	32.5	64.1				100.0	11.7

MAX WIND
SPEED: 21 KNOTS
DIRECTION: 100 DEG
DAY: 18
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 220

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	38.4	57.6	3.8						.9M	2.5M	(13 08)

MAY

DATA SUMMARY — E863

AVERAGE LATITUDE 28.5N — AVERAGE LONGITUDE 080.8W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	21.5	(02 03)	23.6	25.5	(08 00)	51	8

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 52

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N								
NE								
E		3.8	1.9				5.8	12.3
SE		19.2	30.8	3.8			53.8	12.9
S		17.3	15.4	1.9			34.6	12.6
SW		1.9	3.8				5.8	12.7
W								
NW								
CALM								
TOTAL		42.3	51.9	5.8			100.0	12.7

MAX WIND
SPEED: 30 KNOTS
DIRECTION: 140 DEG
DAY: 01
HOUR: 12

MAY

DATA SUMMARY — E870

AVERAGE LATITUDE 58.5N — AVERAGE LONGITUDE 142.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	03.3	(01 06)	06.5	10.2	(18 03)	178	29
SEA TEMP (DEG C)	06.1	(03 12)	07.7	10.5	(17 00)	176	29
AIR-SEA TEMP (DEG C)	-03.0	(01 06)	-01.2	02.3	(18 03)	174	29
PRESSURE (MBAR)	0980.6	(03 00)	1012.4	1027.4	(16 00)	177	29

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 174

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.6	1.1					1.7	3.4
NE		.6	.6				1.1	9.0
E	1.1	5.2	6.3	11.5			24.1	18.2
SE		3.4	8.0	1.7			13.2	14.3
S	.6	2.3	1.7				4.6	9.1
SW	.6	5.2	6.9				12.6	10.7
W	3.4	10.3	18.4		.6		32.8	10.7
NW	1.1	5.2	1.1				7.5	7.5
CALM	2.3						2.3	.0
TOTAL	9.8	33.3	43.1	13.8			100.0	12.3

MAX WIND
SPEED: 28 KNOTS
DIRECTION: 080 DEG
DAY: 18
HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 153

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	14.4	58.8	20.3	5.2	1.3				1.5M	4.5M	(02 15)

JUNE

DATA SUMMARY — E863

AVERAGE LATITUDE 40.8N — AVERAGE LONGITUDE 060.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.4	(06 18)	11.8	15.8	(29 15)	237	30
SEA TEMP (DEG C)	08.1	(01 09)	10.2	11.5	(28 21)	237	30
AIR-SEA TEMP (DEG C)	-00.5	(22 00)	01.7	05.3	(29 15)	237	30
PRESSURE (MBAR)	0980.8	(07 08)	1011.5	1023.0	(14 12)	236	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 234

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N								
NE	.8	2.1	1.3				4.3	7.3
E		1.7	.4				2.1	7.2
SE	.4	7.7	3.4				11.5	8.1
S	.9	6.0	2.1				9.0	7.3
SW	1.3	23.5	8.1				32.9	8.4
W	2.6	18.4	9.8				30.8	8.4
NW	1.7	4.3	2.1				8.1	8.2
CALM	1.3						1.3	.0
TOTAL	8.0	63.7	27.4				100.0	8.1

MAX WIND
SPEED: 18 KNOTS
DIRECTION: 040 DEG
DAY: 11
HOUR: 03

JUNE

DATA SUMMARY — E871

AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 083.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	24.3	(13 03)	27.0	28.5	(24 08)	237	30
SEA TEMP (DEG C)	26.2	(01 12)	27.5	28.9	(08 00)	237	30
AIR-SEA TEMP (DEG C)	-02.6	(13 03)	-00.5	00.5	(24 08)	237	30
PRESSURE (MBAR)	1008.6	(08 00)	1015.2	1018.6	(24 15)	237	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 237

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	3.0					3.4	5.8
NE		3.4	3.8				7.2	8.5
E	.4	8.8	16.9				26.2	11.8
SE		17.3	30.4				47.7	11.9
S		1.3	2.1				3.4	12.4
SW		.4					.4	10.0
W	1.7	3.4	.8				5.9	6.7
NW	.4	4.6	.4				5.5	6.2
CALM	.4						.4	.0
TOTAL	3.4	42.2	54.4				100.0	10.8

MAX WIND
SPEED: 21 KNOTS
DIRECTION: 170 DEG
DAY: 13
HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 234

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	42.7	56.0	1.3						.9M	2.0M	(13 21)

JUNE

DATA SUMMARY — E838

AVERAGE LATITUDE 58.2N — AVERAGE LONGITUDE 152.7W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.1	(27 06)	10.2	11.7	(29 03)	35	5
SEA TEMP (DEG C)	08.8	(26 08)	09.5	10.8	(30 00)	34	5
AIR-SEA TEMP (DEG C)	-00.6	(27 06)	00.8	02.8	(29 03)	34	5
PRESSURE (MBAR)	1012.8	(28 06)	1015.4	1018.4	(29 21)	34	5

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 34

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N								
NE								
E			2.9				2.9	11.1
SE		11.8	11.8				23.5	8.8
S		35.3					35.3	6.5
SW	5.9	8.8					14.7	4.8
W		2.9	11.8				14.7	13.7
NW			8.8				8.8	13.7
CALM								
TOTAL	5.9	58.8	35.3				100.0	8.8

MAX WIND
SPEED: 18 KNOTS
DIRECTION: 280 DEG
DAY: 28
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 33

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	75.8	18.2	6.1						.7M	2.0M	(28 00)

JUNE

DATA SUMMARY — E841

AVERAGE LATITUDE 38.7N — AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	17.2	(24 09)	18.9	23.0	(30 21)	79	11
SEA TEMP (DEG C)	17.3	(21 03)	18.4	22.5	(30 21)	79	11
AIR-SEA TEMP (DEG C)	-02.6	(28 00)	00.5	01.8	(30 06)	79	11
PRESSURE (MBAR)	1005.9	(26 09)	1013.9	1022.1	(24 03)	80	11

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 80

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		2.5					2.5	6.5
NE		6.3					6.3	8.0
E		10.0					10.0	7.1
SE		13.8					13.8	7.6
S	2.5	11.3	1.3				15.0	5.9
SW		17.5	6.3				23.8	9.1
W	1.3	18.8					20.0	7.1
NW		8.8					8.8	7.4
CALM								
TOTAL	3.8	88.8	7.5				100.0	7.5

MAX WIND
SPEED: 14 KNOTS
DIRECTION: 210 DEG
DAY: 29
HOUR: 09

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 81

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	61.7	38.3							.7M	1.5M	(28 18)

Table 8
Selected Gale and Wave Observations, North Atlantic
May and June 1977

Vessel	Nationality	Date	Position of Ship: Lat. deg.	Position of Ship: Long. deg.	Time GMT	Wind: Dir. 10°	Wind: Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C: Air	Temperature °C: Sea	Sea Waves†: Period sec.	Sea Waves†: Height ft.	Swell Waves: Dir. 10°	Swell Waves: Period sec.	Swell Waves: Height ft.
NORTH ATLANTIC OCEAN		MAY															
EXPORT PATRIOT	AMERICAN	2	49.0 N	16.6 W	00	03	35	10 NM	02	1019.0	11.5	11.7	4	10			
WASHINGTON TRADER	AMERICAN	3	39.9 N	55.4 W	21	24	45	.5 NM	65	1011.9	17.5	22.2	7	18	24	10	24.5
WASHINGTON TRADER	AMERICAN	4	39.9 N	55.9 W	00	03	40	2 NM	63	1012.5	15.0	22.2	7	16.5			
STELLA LYKES	AMERICAN	7	37.1 N	28.7 W	18	19	M 35	10 NM	03	1021.4	21.1	16.1	4	5	22	6	6.5
AMER ARCHER	AMERICAN	8	48.8 N	33.8 W	18	25	35	10 NM	03	1005.0	15.0	12.3	5	14.5			
STELLA LYKES	AMERICAN	8	36.7 N	33.1 W	06	22	M 40	10 NM	02	1013.5	18.3	16.7	4	6.5	25	7	8
NOPAL LANE	LIBERIAN	9	47.0 N	36.9 W	06	20	40	2 NM	61	992.0	13.0				20	11	16.5
LONG BEACH	AMERICAN	9	38.5 N	73.8 W	12	33	35	10 NM	02	1001.7	8.8	15.6	8	5			
ARECIBO	AMERICAN	9	38.0 N	73.0 W	18	30	40	5 NM	03	1000.0	8.8	17.7	5	8			
AMER ALLIANCE	AMERICAN	9	48.5 N	35.6 W	18	24	35	5 NM	01	995.7	12.3	13.3	5	13	22	8	16.5
DOCTOR LYKES	AMERICAN	9	45.9 N	37.0 W	18	27	42	10 NM	01	1004.5	11.9	12.8	11	10	23	8	13
AMER LEGEND	AMERICAN	9	45.8 N	33.0 W	12	23	35	2 NM	61	1002.0	13.4	12.3	5	6.5	23	8	13
LONG BEACH	AMERICAN	10	35.7 N	73.9 W	00	34	40	10 NM	02	1006.4	11.2	22.2	8	5			
MORMACTIDE	AMERICAN	10	37.9 N	65.8 W	18	26	45	10 NM	03	997.5	17.8	24.4	11	24.5	26	>13	32.5
MARIA U	LIBERIAN	10	35.8 N	65.2 W	18	24	48	10 NM	02	1003.8	22.2	20.0	5	16.5	24	< 6	23
DOCTOR LYKES	AMERICAN	10	45.1 N	42.0 W	06	27	40	10 NM	02	1012.2	8.3	13.3	5	16.5			
AMER ALLIANCE	AMERICAN	10	47.6 N	40.2 W	06	27	35	10 NM	01	1006.0	6.7	14.0	5	6.5	26	8	13
SANTA ELENA	AMERICAN	10	36.6 N	74.1 W	12	31	38	10 NM	02	1007.2	12.3	20.0	4	10			
ARTLENBERG	GERMAN	11	35.0 N	69.5 W	00	31	40	10 NM	15	1011.0	17.3	23.0	12	19.5			
MARIA U	LIBERIAN	11	35.4 N	66.3 W	00	27	48	10 NM	18	1007.0	20.0	20.0	5	19.5	27	< 6	23
DOCTOR LYKES	AMERICAN	12	41.2 N	61.3 W	06	29	35	10 NM	25	1007.8	8.3	12.2	4	6.5	26	10	14.5
STELLA LYKES	AMERICAN	12	29.2 N	63.8 W	00	03	M 35	5 NM	02	1017.6	17.2	20.0	3	5	35	9	14.5
AFRICAN MERCURY	AMERICAN	13	39.5 N	72.2 W	12	23	35	10 NM	01	1010.7	17.7	17.7	4	10	25	6	13
LIGHTNING	AMERICAN	13	39.1 N	63.9 W	18	22	35	10 NM	03	1001.4	20.0	21.0	2	5	22	7	8
SEALAND PRODUCER	AMERICAN	14	36.8 N	57.2 W	12	25	35	10 NM	01	1010.0	18.8	15.0	5	6.5	23	7	10
LIGHTNING	AMERICAN	14	39.7 N	61.4 W	00	27	35	5 NM	25	999.7	17.3	19.5	2	5	25	7	10
CHASE	AMERICAN	17	40.5 N	67.1 W	18	25	M 35	2 NM	05	1016.8	16.5	12.6	6	10			
SEALAND GALLOWAY	AMERICAN	17	40.7 N	63.9 W	18	27	35	5 NM	02	1014.1	19.5	13.5	6	6.5			
MIDAS RHEIN	LIBERIAN	17	20.6 N	83.5 W	23	09	M 40	10 NM	03	1014.5	31.0	30.0	7	8			
MIDAS RHEIN	LIBERIAN	19	16.2 N	74.4 W	17	09	M 36	2 NM		1011.8	30.0	30.5	6	8			
LASH ITALIA	AMERICAN	19	36.9 N	51.1 W	06	27	35	5 NM	13	1013.8	19.0	15.7	6	8			
MIDAS RHEIN	LIBERIAN	20	14.1 N	69.6 W	17	09	M 39	2 NM	05	1010.8	30.0	31.0	6	10			
CARBIDE SEADRIFT	AMERICAN	23	31.9 N	71.2 W	18	12	35	5 NM	03	1024.0	21.7	22.8	2	5	12	7	10
ROBERTS BANK	LIBERIAN	23	39.6 N	48.0 W	18	28	35	10 NM	15	1020.6	19.0	18.0	2	8	30	8	10
MONMOUTH	AMERICAN	23	31.2 N	79.3 W	12	08	35	1 NM	25	1018.3	25.6	25.7	6	11.5	05	9	13
AMER LEGEND	AMERICAN	24	47.9 N	41.7 W	12	34	35	2 NM	40	1009.8	11.8	13.4	5	6.5	34	8	13
MONMOUTH	AMERICAN	24	33.2 N	76.8 W	00	08	35	1 NM	25	1020.7	23.4	25.4	5	11.5	11	9	14.5
ADM W M CALLAGHAN	AMERICAN	25	48.8 N	38.0 W	18	32	35	10 NM	02	1003.1	7.8	6.1	4	5	36	8	8
SEALAND RESOURCE	AMERICAN	25	49.9 N	35.9 W	18	01	35	5 NM	64	995.0	10.0	11.2	7	11.5			
SEALAND PRODUCER	AMERICAN	28	35.0 N	49.9 W	06	23	40	5 NM	01	1012.5	20.0	16.7	5	8			
LIGHTNING	AMERICAN	29	48.5 N	40.8 W	06	24	35	10 NM	02	1007.1	8.8	13.4	3	6.5	24	7	14.5
JEAN LYKES	AMERICAN	30	45.2 N	39.3 W	06	24	35	5 NM	03	1019.3	15.0	15.6	5	10			
GREAT LAKES VESSELS																	
J BURTON AYERS	AMERICAN	8	43.8 N	82.4 W	18	33	M 42	10 NM	01		4.0	7.0	3	10			
CHARLES M WHITE	AMERICAN	9	43.3 N	82.4 W	00	35	M 40	> 25 NM	02		2.0	3.0	4	11.5			
J BURTON AYERS	AMERICAN	29	42.3 N	80.3 W	06	06	M 38	10 NM	03		10.0	19.0	2	8			
NORTH ATLANTIC OCEAN		JUNE															
EXPORT PATRIOT	AMERICAN	2	46.6 N	36.4 W	18	35	38	2 NM	51	1011.2	12.3	14.0	5	10	02	9	14.5
GUAYAMA	AMERICAN	3	35.7 N	72.1 W	06	20	40	< 50 YD	92	1011.0	18.3	24.4	2	6.5			
EXPORT PATRIOT	AMERICAN	3	46.2 N	38.8 W	00	35	35	5 NM	07	1018.0	14.0	14.0	5	10	35	8	13
LASH PACIFICO	AMERICAN	8	39.6 N	59.4 W	00	24	41	1 NM	80	1006.5	20.0	17.8	3	10	24	6	14.5
NORWALK	AMERICAN	10	36.4 N	71.8 W	12	27	M 36	5 NM	82	1002.0	16.6	25.5	4	6.5	24	8	11.5
CARBIDE SEADRIFT	AMERICAN	10	31.7 N	75.3 W	06	22	35	5 NM	05	1011.2	23.3	23.8			22	6	6.5
DORIC	PANAMANIAN	10	37.4 N	70.2 W	16	27	M 45	10 NM	25	998.0	21.0	25.0	5	10			
SEALAND PRODUCER	AMERICAN	10	38.6 N	65.3 W	18	23	40	10 NM	01	1004.1	22.2	16.7	5	10	20	8	11.5
DORIC	PANAMANIAN	11	38.3 N	71.0 W	00	32	M 45	5 NM	02	1000.5	14.0	22.0	7	16.5			
SEALAND PRODUCER	AMERICAN	11	40.6 N	60.2 W	06	24	40	5 NM	17	1009.1	17.7	20.0	5	10	20	8	11.5
STAGHOUND	AMERICAN	13	49.1 N	28.5 W	00	35	36	10 NM	02	1015.9	12.3	14.5	6	8			
SEALAND PRODUCER	AMERICAN	14	46.9 N	20.0 W	18	09	M 45	5 NM	81	1015.0	14.5	12.3	5	14.5			
EVERGREEN	AMERICAN	18	51.7 N	52.6 W	18	31	M 45	1 NM	62	996.4	4.4	3.0	4	21			
ESSO ANTWERP	BELGIAN	20	14.3 N	71.7 W	06	03	M 40	5 NM	02	1013.0	27.3	27.8	8	10			
AMER LEGION	AMERICAN	21	11.6 N	78.8 W	00	06	35	5 NM	02	1011.5	27.8	27.2	5	6.5	04	7	10
AFRICAN MERCURY	AMERICAN	23	17.9 N	28.9 W	18	04	35	5 NM	02	1018.4	25.6	23.4			06	6	10
SOUTHWARD	NORWEGIAN	24	20.0 N	74.2 W	06	05	35	10 NM	02	1017.0	28.1	31.0					
SEALAND PRODUCER	AMERICAN	24	36.2 N	46.8 W	12	18	35	5 NM	03	1022.0	25.0	18.8	5	6.5	23	6	8
SEALAND RESOURCE	AMERICAN	28	40.3 N	64.2 W	12	29	35	10 NM	01	1014.0	19.5	24.4	7	11.5			
AMER LYNX	AMERICAN	29	16.6 N	76.2 W	18	08	35	5 NM	03	1015.0	29.4	26.8	3	8	08	< 6	11.5
SOUTHWARD	NORWEGIAN	30	19.9 N	74.4 W	06	08	35	10 NM	03	1018.0	27.1	31.0					
AMER ASTRONAUT	AMERICAN	30	13.8 N	77.5 W	00	08	35	5 NM	02	1013.2	27.2	27.2	7	11.5			
GREAT LAKES VESSELS																	
G M HUMPHREY	AMERICAN	6	43.9 N	82.6 W	12	04	M 35	2 NM	63		7.0	4.0	6	5			
JOHN DYKSTRA	AMERICAN	6	43.4 N	82.6 W	18	30	M 43	10 NM	60		8.0	12.0	7	6.5			

† Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Table 9
Selected Gale and Wave Observations, North Pacific
May and June 1977

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C.		Sea Waves†		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		MAY															
JAPAN RAINBOW	JAPANESE	1	49.2 N	170.2 E	06	27	M 35	1 NM	05	1000.6	1.0	5.0					
PRES VAN BUREN	AMERICAN	1	35.1 N	143.6 E	06	23	35	10 NM	01	1021.2	20.5	18.3	3	6.5			
TRANSONEIDA	AMERICAN	1	38.1 N	146.5 W	06	36	37	10 NM	02	1018.0	10.0	13.9	6	8	34	10	11.5
NEWARK	AMERICAN	2	57.0 N	145.2 W	06	14	35	5 NM	21	983.7	3.9	5.0	5	10	19	8	13
PHILADELPHIA	AMERICAN	2	51.0 N	130.2 W	18	16	45	2 NM	21	998.0	10.6	6.0	8	13			
FERNSIDE	NORWEGIAN	2	38.9 N	148.7 E	12	21	45	5 NM	02	999.5	14.5	12.0	7	14.5			
SEALAND FINANCE	AMERICAN	2	36.6 N	142.4 E	00	23	35	2 NM		1005.8	16.7	16.2	5	8			
LAUREL	LIBERIAN	3	40.6 N	166.6 E	12	20	M 44	2 NM	10	999.7	12.0	13.0	4	8	21	< 6	11.5
PHILADELPHIA	AMERICAN	3	50.2 N	128.2 W	00	14	45	2 NM	21	1000.0	10.7	6.5	3	8	14	8	13
PRESIDENT MADISON	AMERICAN	3	38.7 N	174.3 W	12	35	M 35	10 NM	02	1020.2	10.0	12.2	7	10	05	9	23
RACHEL	LIBERIAN	3	38.0 N	175.5 W	06	33	35	5 NM	02	1018.0	11.0	14.0	4	10			
SEVILLAN REEFER	LIBERIAN	3	34.9 N	153.4 E	06	25	35	2 NM	80	1007.0	16.0	17.0	5	10			
ARCO FAIRBANKS	AMERICAN	3	53.7 N	156.0 W	00	27	M 35	10 NM	01	999.3	6.5	3.9	5	10	XX		11.5
AMER CORSAIR	AMERICAN	3	35.2 N	164.2 E	12	16	45	5 NM	60	1012.5	16.7	16.1	5	8			
FERNSIDE	NORWEGIAN	3	38.9 N	146.6 E	00	28	45	> 25 NM	01	1001.5	14.8	12.0	5	11.5	16	6	14.5
													7	14.5	26	7	14.5
HONGKONG MAIL	AMERICAN	3	42.5 N	171.0 E	18	21	38	2 NM	60	992.9	11.7	6.7	5	10	21	9	19.5
JAPAN RAINBOW	JAPANESE	3	43.3 N	155.4 E	12	33	M 40	2 NM	83	1005.0	0.0	2.0					
ALEUTIAN DEVELOPER	AMERICAN	4	53.6 N	169.5 W	12	18	40	1 NM	52	999.5	3.9	5.0	4	10	19	13	13
JOTUNF JELL	NORWEGIAN	4	45.0 N	178.4 W	06	19	52	2 NM	58	1001.0	9.0	10.0					
INDIAN MAIL	AMERICAN	4	50.3 N	175.0 W	18	24	43	2 NM	15	995.0	3.3	2.2	4	10	23	9	34.5
HONGKONG MAIL	AMERICAN	4	43.3 N	172.6 E	00	24	40	5 NM	01	994.2	9.4	5.6	6	10	24	9	19.5
NORTH STAR III	AMERICAN	4	53.3 N	168.7 W	12	09	55	1 NM	65	1001.4	5.6	5.6					
PACIFIC VENTURE	PANAMANIAN	5	53.8 N	171.2 W	18	22	M 40	2 NM		995.8	5.5	3.5	8	16.5			
ALEUTIAN DEVELOPER	AMERICAN	5	52.2 N	175.1 W	12	21	48	5 NM	02	999.0	3.9	5.0	3	6.5	21	10	13
INDIAN MAIL	AMERICAN	5	50.0 N	176.5 W	06	24	41	5 NM	02	997.7	3.3	2.2	6	13	23	11	31
JOTUNF JELL	NORWEGIAN	5	45.2 N	178.8 E	00	28	35	10 NM	03	1009.0	8.0	10.0					
NORTH STAR III	AMERICAN	5	53.6 N	168.2 W	00	22	40	5 NM	01	998.3	6.1	4.4	8	8			
MILLER FREEMAN	AMERICAN	5	54.1 N	165.8 W	00	12	M 40	2 NM	07	998.3	6.0	5.6		5			
ARCO PRUDHOE BAY	AMERICAN	6	52.6 N	133.4 W	12	32	35	> 25 NM	02	1014.8	7.4	7.2	6	14.5			
INDIAN MAIL	AMERICAN	6	50.9 N	168.4 W	00	23	30	10 NM	15	1014.3	7.8	2.2	5	11.5	21	9	26
NORTH STAR III	AMERICAN	6	53.4 N	167.8 W	00	23	40	10 NM	02	1007.2	4.4	6.1	3	6.5			
ZIM NEW YORK	GERMAN	7	35.7 N	162.0 E	00	17	35	5 NM	02	1012.4	16.5	16.1	7	18			
PRES PIERCE	AMERICAN	7	37.9 N	167.9 E	18	16	45	1 NM	60	1017.0	14.4	15.0	6	13			
JOTUNF JELL	NORWEGIAN	8	43.3 N	153.3 E	18	27	37	5 NM	02	1006.0	4.0	6.0					
J L HANNA	AMERICAN	8	42.1 N	124.7 W	18	36	35	> 25 NM	02	1015.0	13.3	11.7	2	3	36	< 6	8
SAN BRUNO	SWEDISH	9	33.8 N	125.9 W	00	34	35	10 NM	03	1010.0	17.0		5	5	34	8	6.5
ARCO FAIRBANKS	AMERICAN	9	45.6 N	164.3 E	06	23	M 35	5 NM	07	1006.5	9.5	2.3	5	8			
JOTUNF JELL	NORWEGIAN	9	43.1 N	152.1 E	00	30	37	10 NM	03	1010.0	2.0	3.0					
PRES JEFFERSON	AMERICAN	9	38.0 N	159.5 W	06	04	35	5 NM	15	1031.8	10.6	12.2	4	8	07	7	14.5
SEALAND EXCHANGE	AMERICAN	10	50.9 N	170.5 W	12	20	35	5 NM	02	1011.7	4.8	3.3	5	5			
ALEUTIAN DEVELOPER	AMERICAN	12	58.4 N	150.9 W	06	04	35	10 NM	02	1002.3	7.5	5.5	5	6.5			
GRAND CARRIER	LIBERIAN	13	41.7 N	172.2 E	12	34	M 40	5 NM	05	1017.6	10.0	5.0					
NEWARK	AMERICAN	13	50.1 N	128.2 W	00	13	45	5 NM	25	1007.8	5.5	8.9	9	10	27	< 6	6.5
MONTANA	AMERICAN	13	31.7 N	154.3 E	18	07	35	5 NM	61	1005.0	17.2	18.9	5	10	10	7	13
GRAND CARRIER	LIBERIAN	14	43.5 N	179.9 W	12	32	M 40	10 NM	03	1013.7	6.0	6.0					
ARTHUR MAERSK	DANISH	14	33.5 N	162.8 E	06	08	36	1 NM	63	1003.2	17.5		6	24.5			
PACIFIC ERA	LIBERIAN	14	34.1 N	155.5 E	18	05	40	.25 NM	60	1004.2	16.5	19.0	7	26			
MONTANA	AMERICAN	14	30.7 N	156.2 E	00	04	44	2 NM	51	1000.7	16.2	18.9	6	16.5	06	9	29.5
ARTHUR MAERSK	DANISH	15	32.3 N	154.9 E	00	01	36	2 NM	60	998.5	19.0		11	19.5			
PACIFIC ERA	LIBERIAN	15	34.2 N	153.5 E	06	03	35	5 NM	02	1007.0	18.0	19.0	7	24.5			
JAPAN BEAR	AMERICAN	16	37.6 N	124.0 W	12	34	M 40	10 NM	02	1017.4	11.1	8.9	5	14.5			
PRES QUEZON	PHILIPPINE	16	33.8 N	122.4 W	12	33	35	.5 NM	05	1020.0	13.5	15.0	5	14.5	28	< 6	11.5
SEALAND MC LEAN	AMERICAN	16	37.2 N	158.2 E	00	07	40	2 NM	05	1002.5	15.0	13.9	6	10			
MAYA PIONEER	JAPANESE	16	51.5 N	132.5 W	12	32	36	> 25 NM	01	1023.0	8.0	8.0					
NEWARK	AMERICAN	16	53.0 N	134.2 W	12	31	35	10 NM	03	1024.7	6.7	8.8	5	10	31	7	13
AMER LARK	AMERICAN	17	40.5 N	160.7 E	06	12	M 36	5 NM	02	1012.2	12.3	10.0	5	11.5	11	8	14.5
SAN BRUNO	SWEDISH	17	36.8 N	156.3 E	12	17	35	1 NM	59	1002.5	17.9		5	14.5			
PRESIDENT MADISON	AMERICAN	17	42.8 N	168.2 W	06	35	M 36	1 NM	21	1005.7	6.7	11.7	7	16.5			
MENINA ALICE	PANAMANIAN	17	45.7 N	151.2 E	06	08	M 35	.25 NM	45	1011.0	2.0	1.0	6	10	12	10	16.5
GRAND CARRIER	LIBERIAN	18	48.0 N	144.2 W	18	25	M 35	10 NM	01	1008.0	8.0	6.5					
MAYA PIONEER	JAPANESE	18	53.9 N	154.2 W	18	27	M 40	5 NM	23	989.0	5.5	4.0	7	11.5			
PHILADELPHIA	AMERICAN	18	58.5 N	148.6 W	06	11	60	5 NM	21	1000.3	7.2	6.1	10	14.5	11	10	19.5
ALASKA STANDARD	AMERICAN	18	59.2 N	152.0 W	12	09	40	1 NM	65	987.8	5.5	10.0	3	5			
PRES TAFT	AMERICAN	19	54.1 N	149.8 W	12	26	38	10 NM	18	1004.8	4.4	3.9	5	10	25	8	14.5
MAYA PIONEER	JAPANESE	19	53.6 N	155.1 W	00	25	M 37	> 25 NM	02	993.0	8.3	5.0	6	13			
GREAT LAND	AMERICAN	19	55.9 N	140.5 W	12	25	M 40	10 NM	01	1007.8	7.8	6.8					
VIOLET	LIBERIAN	20	37.2 N	143.8 E	00	32	M 45	10 NM	02	1006.0	19.0	20.0	5	13			
PRES TAFT	AMERICAN	21	54.4 N	175.7 W	06	27	35	5 NM	83	1001.0	4.5	1.7	3	5	27	7	11.5
ATLANTIC PIONEER	PANAMANIAN	21	39.6 N	147.6 E	00	34	M 35	5 NM	02	1001.5	9.0	15.0	5	10			
GREAT LAND	AMERICAN	22	53.2 N	134.0 W	18	16	M 40	5 NM	80	1001.7	7.8	10.0	7	10			
AVILA	AMERICAN	23	24.2 N	151.3 W	00	06	M 35	10 NM	02	1023.0	22.2	21.7	3	5	09	10	8
ATLANTIC PIONEER	PANAMANIAN	23	46.5 N	162.8 E	06	07	M 35	.5 NM	40	1006.5	6.0	7.0	5	10			
ASIA BRIGHTNESS	LIBERIAN	24	39.8 N	157.2 E	00	34	35	5 NM	02	1007.0	10.0	14.0	5	19.5			
OCEANOGRAPHER	AMERICAN	25	43.0 N	125.2 W	18	18	M 36	5 NM	63	1008.1	11.7	12.4	4	6.5	19	7	10
ATLANTIC PIONEER	PANAMANIAN	25	50.9 N	178.7 W	12	08	M 35	5 NM	02	1013.5	5.0	4.0	4	8			
S P LEE	AMERICAN	26	43.3 N	124.5 W	00	19	M 37	.5 NM	25	1005.5	11.7	12.0	5	6.5	19	6	10
OCEANOGRAPHER	AMERICAN	26	43.0 N	125.0 W	00	17	M 45	2 NM	61	1006.7	11.5	12.4	5	11.5			
VAN WARRIOR	LIBERIAN	27	48.5 N	129.5 W	00	18	45	.25 NM	63	997.0	10.0	12.0					
ASIA BEAUTY	LIBERIAN	27	50.5 N	129.8 W	00	14	M 40	2 NM	50	997.0	8.0	8.0	10	16.5	32	9	21
GALVESTON	AMERICAN	27	50.6 N	130.8 W	00	15	45	10 NM	80	993.5	8.3	8.9	6	14.5	13	8	18
CORAL ARCADIA	LIBERIAN	27	50.2 N	129.3 W	06	14	M 38	5 NM	63	994.5	8.0	10.5	10	18			
LONG BEACH	AMERICAN	28	35.8 N	121.9 W	12	32	35	10 NM	02	1015.9	11.2	16.7	6	5			
LONG BEACH	AMERICAN	29	33.2 N	120.1 W	00	34	35	10 NM	02	1012.5	15.6	11.7	6	5			
JAPAN CADBO	LIBERIAN	29	37.9 N	176.7 E	12	12	37	5 NM	61	1017.8	13.0	9.0	5	11.5	11	< 6	14.5
COLORADO	AMERICAN	29	33.3 N	162.5 E	12	04	35	10 NM	02	1012.1	16.1	15.6	2	5	05	7	16.5
ZIM MONTREAL	LIBERIAN	30	39.1 N	175.6 E	18	36	35	2 NM	10	998.5	12.5	15.0	5	8	04	7	10
JAPAN CADBO	LIBERIAN	30	37.8 N	176.8 E	12	10	39	2 NM	62	1008.6	14.0	12.0	5	18	10	7	24.5
PLUTOS	GERMAN	31	37.7 N	175.7 E	06	30	40	5 NM	01	1004.0	13.2	12.0	6	13			
PACIFIC ARROW	JAPANESE	31	41.9 N	177.0 W	00	10	M 37	.5 NM	61	1007.8	10.0	11.9	4	8	12	9	16.5

Vessel	Nationality	Date	Position of Ship Lat. deg.	Long. deg.	Time GMT	Wind Dir. 10°	Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Sea	Sea Waves+ Period sec.	Height ft.	Swell Waves Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		MAY															
ALBERT MAERSK	DANISH	31	44.0 N	165.8 W	18	12	38	5 NM	02	1012.0	12.0		10	19.5			
MICHIGAN	AMERICAN	31	36.5 N	179.1 E	18	28	41	10 NM	03	1010.3	20.0	16.7	6	11.5			
NORTH PACIFIC OCEAN		JUNE															
HIEI MARU	JAPANESE	1	42.9 N	153.1 W	18	11	M 39	5 NM	61	1010.5	11.0	10.5			13	6	6.5
MEADOWBROOK	AMERICAN	1	15.1 N	94.9 W	12	34	50	10 NM	01	1009.5	27.8	30.5	6	16.5			
ALBERT MAERSK	DANISH	1	43.8 N	157.6 W	12	12	38	5 NM	60	1000.9	10.0		10	19.5			
ALBERT MAERSK	DANISH	2	43.2 N	152.1 W	00	13	36	1 NM	62	1000.8	12.0	9.0	10	16.5			
PRES JEFFERSON	AMERICAN	3	39.6 N	149.1 E	06	15	35	.5 NM	61	1007.5	15.6	15.6	5	8			
MAINE	AMERICAN	3	33.5 N	172.8 E	06	20	45	2 NM	14	993.9	17.5	16.7	7	16.5	15	< 6	6.5
PRES JOHNSON	AMERICAN	3	35.2 N	165.2 E	06	02	36	5 NM	02	1013.9	14.4	15.0	8	11.5	08	>13	19.5
PLUTOS	GERMAN	3	34.9 N	146.3 E	06	18	40	2 NM	10	1006.8	19.9	20.5	4	10	18	12	14.5
ARILD MAERSK	DANISH	3	36.7 N	175.7 E	00	11	50	.25 NM	47	1008.2	16.8		10	26			
SAN BRUNO	SWEDISH	3	36.4 N	146.2 E	06	19	40	1 NM	65	1006.0	22.1		5	13	17	11	19.5
AMER LEGION	AMERICAN	3	36.1 N	152.0 E	00	16	35	10 NM	02	1019.3	20.0	17.8	6	10			
OJI GLORIA	LIBERIAN	3	40.5 N	148.0 E	06	18	M 42	1 NM	18	1003.0	13.0						
KOREA PHOENIX	SINGAPORE	4	51.5 N	146.3 W	23	23	M 44	5 NM	02	1006.5	7.5		5	8	02	8	8
MAINE	AMERICAN	4	33.8 N	165.4 E	06	33	35	10 NM	02	1006.3	15.0	17.3	6	10	05	9	13
KOREA PHOENIX	SINGAPORE	5	51.3 N	144.1 W	05	09	M 40	2 NM	02	1009.5	7.5		5	6.5	09	10	8
CHEVRON COLORADO	AMERICAN	9	38.8 N	125.4 W	06	33	M 42	10 NM	02	1009.5	12.8		7	10	33	7	13
MODOC	AMERICAN	9	42.7 N	124.6 W	18	33	50	5 NM	07	1007.4	10.5	11.3	7	10	33	8	14.5
ATLANTIDE	SWEDISH	10	14.6 N	94.6 W	18	35	40	2 NM	64	1013.0	25.0	28.0	7	5			
PRES TAFT	AMERICAN	10	44.9 N	149.6 W	00	17	35	.25 NM	43	1020.5	10.0	7.2	4	8	18	7	13
ATLANTIC PIONEER	PANAMANIAN	11	50.0 N	130.6 W	06	32	M 35	2 NM	02	1022.0	12.0	10.0	4	10	32	9	10
PRESIDENT MADISON	AMERICAN	14	50.0 N	165.9 W	06	13	M 40	5 NM	51	993.0	10.0	6.6	6	18			
SEALAND MC LEAN	AMERICAN	14	54.2 N	166.8 W	18	09	37	10 NM	02	996.2	7.7	5.0	5	8			
INGER	AMERICAN	15	41.6 N	124.7 W	06	35	35	10 NM	02	1018.0	12.2	11.2			34	< 6	10
PRESIDENT MADISON	AMERICAN	16	49.8 N	138.0 W	06	15	M 40	5 NM	61	1016.0	5.6	10.0	8	14.5			
ARNOLD MAERSK	DANISH	17	35.7 N	145.5 E	06	08	35	5 NM	81	1003.5	19.6	20.0	5	18			
VAN CONQUEROR	LIBERIAN	18	34.3 N	138.5 E	18	05	M 40	5 NM	02	1003.0	21.0	23.0					
MONTANA	AMERICAN	18	31.3 N	154.8 E	06	23	35	5 NM	05	1008.9	22.2	20.6	4	6.5	26	< 6	10
AMER LYNX	AMERICAN	19	38.0 N	124.5 W	18	34	40	10 NM	02	1017.1	12.8	15.6	7	13			
MONTANA	AMERICAN	19	29.8 N	145.2 E	06	21	35	10 NM	02	1005.8	25.6	25.0	4	6.5	21	6	10
PRES TAFT	AMERICAN	19	39.3 N	124.7 W	18	34	45	5 NM	02	1016.3	14.4	10.0	8	10	33	10	16.5
PRES TAFT	AMERICAN	21	48.0 N	140.8 W	12	27	35	10 NM	03	1011.0	10.0	9.4	8	10			
PRESIDENT MADISON	AMERICAN	21	53.8 N	150.0 W	18	28	M 35	5 NM	20	1003.2	10.0	7.8	6	10			
KANA KFOKI	AMERICAN	22	40.0 N	163.9 E	18	04	M 40	2 NM	07	1005.5	11.7		5	6.5	04	6	13
JAMAICA MARU	JAPANESE	22	44.7 N	160.1 W	18	27	M 40	2 NM	61	990.3	10.0	10.5	3	6.5	27	8	13
PRES TAFT	AMERICAN	22	50.2 N	146.7 W	00	25	35	10 NM	03	1015.3	10.6	7.2	7	8	25	9	13
JAMAICA MARU	JAPANESE	23	44.6 N	158.0 W	00	27	M 48	1 NM	53	994.3	9.0	10.0	5	11.5	27	9	18
ZIM MONTREAL	LIBERIAN	23	43.6 N	160.0 W	00	27	35	10 NM	02	1004.5	10.0	11.0	4	8	29	7	14.5
ORIENTAL COMMANDER	LIBERIAN	23	38.0 N	171.5 E	06	25	40	.5 NM	45	1004.8	15.0		6	10	25	8	19.5
SHINYO MARU	JAPANESE	23	43.3 N	149.8 W	06	25	M 38	10 NM	01	1003.5	12.5	10.5	6	11.5	24	9	16.5
NEVADA	AMERICAN	23	37.1 N	165.5 E	00	29	34	5 NM	02	1011.5	15.0	15.5	XX	13	29	6	24.5
PRES JOHNSON	AMERICAN	23	49.5 N	135.5 W	12	10	35	5 NM	81	1007.5	10.0	10.0	5	8			
ARNOLD MAERSK	DANISH	23	42.9 N	149.9 W	06	24	41	5 NM	01	1006.0	13.5		6	19.5			
CHESTNUT HILL	AMERICAN	23	45.0 N	150.0 W	12	24	45	5 NM	02	993.5	8.8	10.6	3	10	23	< 6	19.5
PRES JOHNSON	AMERICAN	24	48.9 N	128.6 W	00	18	35	1 NM	25	1015.9	11.7	11.7	5	8			
CHESTNUT HILL	AMERICAN	24	44.3 N	150.0 W	00	25	40	5 NM	01	1009.1	11.6	10.0	4	10	25	< 6	19.5
JAPAN BEAR	AMERICAN	24	42.7 N	160.0 W	18	25	M 40	2 NM	07	995.2	11.1	10.0	5	19.5			
PLUVIUS	GERMAN	25	47.7 N	155.6 W	00	10	37	1 NM	65	992.5	9.5	8.3	7	11.5			
JAPAN BEAR	AMERICAN	25	42.2 N	157.3 W	00	27	M 30	10 NM	01	1008.0	15.6	10.0	6	26			
CALIFORNIAN	AMERICAN	25	37.5 N	123.2 W	18	34	38	1 NM	10	1014.2	11.7	17.7	3	6.5	34	6	11.5
YAMASHIN MARU	JAPANESE	26	45.2 N	161.3 W	12	01	M 44	2 NM	63	1000.0	7.5	7.0	4	6.5	05	7	13
PACIFIC ARROW	JAPANESE	26	44.0 N	155.0 W	18	22	M 42	2 NM	02	1003.5	14.0		5	13			
PLUVIUS	GERMAN	26	46.0 N	144.7 W	00	26	37	5 NM	02	1014.8	10.8	9.8	7	11.5	24	9	16.5
YAMASHIN MARU	JAPANESE	27	44.9 N	155.3 W	00	27	M 47	2 NM	02	1006.0	10.0	7.0	4	6.5	23	12	26
THOMAS E CUFFE	AMERICAN	27	45.0 N	149.5 W	06	23	40	10 NM	02	1013.0	10.0	10.6	2	6.5	23	6	14.5
PACIFIC ARROW	JAPANESE	27	44.0 N	157.2 W	00	28	M 38	5 NM	01	1013.6	12.0	9.5	6	6.5	26	8	16.5
KOREA PHOENIX	SINGAPORE	27	27.2 N	122.3 E	05	22	M 37	2 NM	10	1003.5	28.0		4	5	22	8	5
PRES MCKINLEY	AMERICAN	28	45.4 N	153.9 W	18	06	35	2 NM	62	1012.0	7.8	8.9	5	11.5			
PLUTOS	GERMAN	29	39.9 N	166.2 E	18	02	40	5 NM	03	1011.6	15.0	14.3	6	8	09	8	10
MIDGETT	AMERICAN	29	41.1 N	125.6 W	06	36	M 41	5 NM	01	1015.2	12.3	5.6	4	5			
PLUTOS	GERMAN	30	39.9 N	163.6 E	00	36	36	10 NM	02	1017.0	11.8	14.4	6	8	08	10	13
CHEVRON COLORADO	AMERICAN	30	42.1 N	124.7 W	12	34	M 35	2 NM	01	1009.2	10.0		4	6.5	33	8	14.5

+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Rough Log, North Atlantic Weather

August and September 1977

ROUGH LOG, AUGUST 1977--The primary path of the storm centers was north of the major shipping lanes as climatology indicates. The major track extended from Lake Winnipeg across southern Canada to north of Hamilton Inlet on the Labrador coast. From there it paralleled the 57th parallel to dissipate south of Iceland. A few storms continued across Scotland and into the Norwegian Sea. One LOW approached the English Channel early in the month, and later two centers moved over the Channel. The east coast of the United States was very quiet with only one system along the southeast section.

Over the ocean area the mean sea-level-pressure pattern was near normal. Except for a small area east of Kap Farvel, the pressures were above the climatic mean. The significant difference in the pattern was a 1007-mb LOW over Hudson Bay. This produced a minus 4-mb anomaly in that area and reflected the passage of above-normal LOWs through the area. A 1009-mb LOW near 60°N, 30°W, marked the Icelandic LOW. The Bermuda-Azores High was 1026 mb and 3 mb higher than the climatic mean. This higher central pressure was reflected over most of the ocean and along the U. S. East Coast.

The upper air pattern differed from climatology mainly over the eastern United States and Canada. As with the surface there was an anomalous LOW over Hudson Bay, which drew the trough normally over the coast westward to the longitude of the Great Lakes. The height of the 700-mb surface was generally higher than normal over the water area.

The average number of tropical waves--10--were traced across the tropical Atlantic from Africa during the month. The first tropical depression appeared on the 29th, and it quickly developed into hurricane Anita on the 30th. This was the latest actual beginning of the hurricane season since 1967, when the first storm was named on the 30th. The first tropical storm has developed later than August 31 only five times in this century.

Extratropical Cyclones--The Bermuda-Azores High was the predominant circulation feature this month. The central pressure was generally greater than 1025 mb and wandered from near Bermuda to north of the Azores Islands. The majority of the low-pressure centers were weak and did not develop large circulations.

The first LOW of any consequence moved over Newfoundland on the 1st. It traveled slowly in a northeasterly direction until the 3d, when under zonal flow it raced toward Scotland. As it approached longitude 15°W, a ship near 56°N, 12°W, reported 35-kn easterly winds.

On the 5th as the storm moved northward off Bergen, Norway (fig. 48), two ships again reported 35-kn winds with the GUIY fighting 16-ft seas. At 1800 her winds were 44 kn and seas 23 ft. Many ships, probably fishing vessels, reported gales. The LOW was now 997 mb--the lowest pressure thus far. By midday on the 7th, it was 984 mb at 70°N midway between the Greenland and Norwegian coasts. Jan Mayen Island had 40-kn winds with fog, while two coastal stations off northern Norway had 40-kn winds with rain. Ocean Station Vessel Mike measured 36-kn winds. At 1800 the winds were 40 kn and the seas 20 ft. On the 8th the seas increased to 23 ft. By late on the 10th, the storm had disappeared.

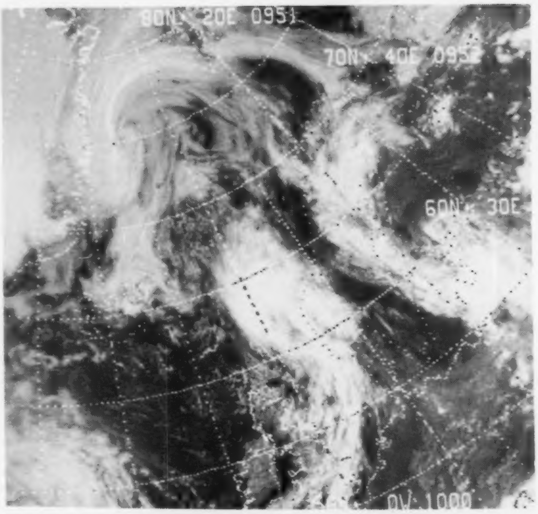
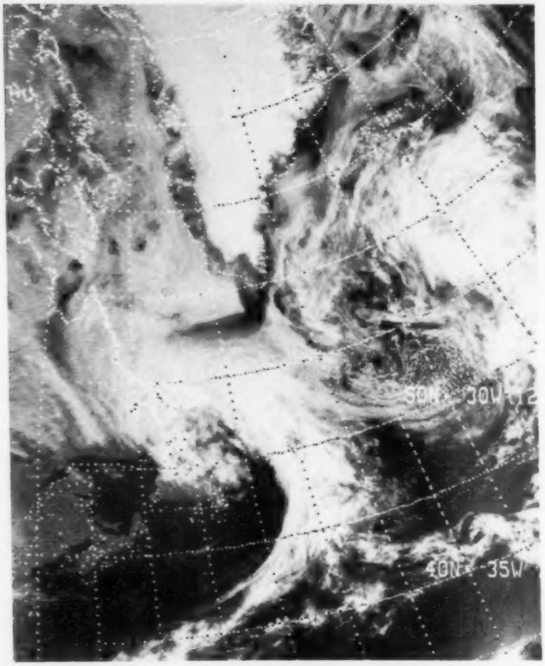


Figure 48.--The storm is centered between Bergen, Norway, and the Shetland Islands with no distinct center to identify it. A storm of more classic appearance is off northeastern Greenland.

This LOW developed north of the Great Lakes on the 8th. As it moved over the Gulf of St. Lawrence on the 9th, it intensified. On the 10th the USNS PVT J. R. TOWLE in the Labrador sea was hit by 50-kn winds (fig. 49). Two ships over the Grand Banks had gales up to 40 kn. As the storm moved along and north of the shipping lanes, it developed one of the larger cyclonic circulations for this month. The central pressure was only 992 mb, and the winds were light.

On the 13th the storm turned northward and then westward on the 14th. On the 15th the SHACKLETON was south of Iceland with 40-kn winds and 20-ft seas. By the 16th the LOW dissipated on the coast of Greenland.

On the 18th a front out of a LOW over the Gulf of St. Lawrence moved off the U. S. East Coast. The Bermuda-Azores High at 1030 mb was centered near the Azores Islands. As the front moved eastward, the gradient east of the front increased; the DART AMERICA and two U. S. S. R. ships reported gales of 35 to 40 kn along a line from near 32°N, 68°W, to 40°N,



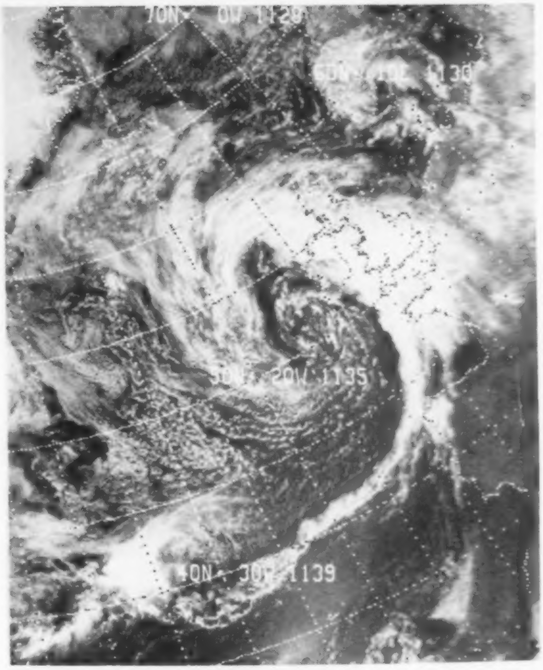


Figure 49.--The LOW is north of Newfoundland, but the interesting feature of this image is the fog and/ or stratus off western Greenland. Note the straight sides and square corner of the formation southwest of Kap Farvel.

Figure 50.--The LOW appears to be centered near 52°N, 13°W. Ocean Weather Station Romeo had partly sunny skies as she rode out the high waves near 47°N, 17°W.

62°W. A few hours later the gradient relaxed with light winds.

Monster of the Month--The Bermuda-Azores High had stubbornly remained fixed near 35°N, 35°W, at about 1031 mb for several days. The same front mentioned above had just as stubbornly persisted on the northwestern quadrant. Stable frontal waves generated and dissipated along the front. At 1200 on the 21st, the ULTRASEA reported 18-ft swells in the southwesterly flow east of the front. Six hours later another frontal wave was detected near the Flemish Cap. This one was unstable and continued to develop.

The center passed slightly south of OWS Charlie late on the 22d. Charlie measured nearly 40-kn winds which shifted from east to north as the storm moved eastward. At 1200 on the 23d, the BISCHOFSTOR (47.4°N, 30.3°W) reported westerly winds of 76 kn. Not far away at 48.5°N, 30.1°W, the PAVLOGRAD had westerly 46-kn winds, and on the east side of the LOW the DART ATLANTIC (49.9°N, 11.5°W) reported southeasterly 40-kn gales. The highest seas were 13 ft.

By 1200 on the 24th, the LOW was 986 mb near 54°N, 14°W--now a fairly large storm stretching from Iceland to Portugal. OWS Romeo measured 40-kn gales and 26-ft seas (fig. 50). Other ships were reporting gales with seas around 15 ft. Twelve hours later Romeo was riding 30-ft seas. At 1200 on the 25th, the VALERIAN KUYBYSHEV also found 30-ft swells southeast of Romeo. The NEPTUNUS in the southwest quadrant (49°N, 21°W) was sailing with 40-kn winds and 20-ft waves. The 992-mb LOW was over the North Sea on the 26th, while OWS Romeo was again fighting 40-kn gales with 34-ft seas. Early in the morning a new LOW formed south of Ireland and kept the pressure gradient tight near the western shores. On the 27th both LOWs disintegrated.

As a front moved off the United States-Canadian coast on the 25th, a wave formed over Nova Scotia. It traveled northeastward becoming a 990-mb storm over the Labrador Sea. At 0000 on the 27th Kap Farvel reported 35-kn gales. Can you imagine -22°C temperature in the Northern Hemisphere at this time of year? That was what the thermometer read at a station on the Greenland Ice Cap near 65°N, 44°W.

At 1200 on the 27th, a ship near 57°N, 20°W, was sailing into 40-kn gales with 13-ft seas. A station on the southern coast of Iceland measured 35-kn gales. A U. S. S. R. -registered ship found 40-kn gales from the south while east of the cold front near 61°N, 15°W. To the south, OWS Lima measured 13-ft swells. On the 28th the 982-mb LOW was over Iceland. A ship off the southern coast had 16-ft swells. Several ships in the North Sea were now reporting 40-kn gales as were Icelandic fishing vessels north of the island. On the 29th two ships reported swell waves of over 20 ft south of Iceland. On the 30th the LOW moved into the Barents Sea.

This was one of the few storms in which the center originated over or even tracked across the United States. It started over Colorado on the eastern slopes of the Rocky Mountains on the 27th. It was over Labrador 48 hr later. At 1200 on the 31st the 984-mb LOW was near 57°N, 30°W. Five ships reported gales of 35 to 45 kn south of the center, including OWS Charlie who reported 18-ft seas.

By 0000 on September 1 the seas had increased to 25 ft at Charlie, and the VOLJANINE nearby at 53.5°N, 35.3°W, had 50-kn winds and 23-ft seas. By 1200 the LOW was 972 mb near 58°N, 21°W. It was now in the British zone of influence. The C. P. TRADER (52.5°N, 23°W) reported towering 33-ft swells (fig. 51). Close by the RUBENS had 45-kn westerlies. Very near the center the UNIWERS WROCLAWSKI with a pressure of 978 mb had howling 60-kn southeasterly winds. No waves were reported. On the 2d the winds continued to blow at 35 to 40 kn with the seas approaching 20 ft at times. On the 3d the LOW was over the Greenland Sea.

Tropical Cyclones--The origin of Anita was a tropical wave in the Atlantic trades that moved off the African coast on August 16. This was the 30th wave of the 1977 hurricane season. Similar to many of the other perturbations seen at this time of the year, it traveled westward across the tropical North Atlantic at 15 kn. Cloudiness and showers associated with this system spread across the Bahamas on the 25th and 26th and over Florida and western Cuba on the 27th. Disturbed weather persisted for several days over southern Florida and the northern Bahamas and produced several inches of rain. This weather appears to have been part of the overall weather system from which Anita developed. On the 28th the system shifted into the eastern Gulf of Mexico, where the upper tropospheric circulation was mainly anticyclonic and conducive to development of a warm-core tropical system.

The next day a concentrated area of convection was over the east-central Gulf of Mexico, and a tropical depression formed within this cloud mass by 1200. Its center was 210 mi south-southwest of New Orleans at this time. The storm moved west-southwestward for the next 4 days, intensifying steadily. Anita attained tropical-storm strength just before 0600 on the 30th and reached hurricane force 12 hr later. Strengthening continued until a minimum pressure of 926 mb was measured just prior to landfall. This was the fourth lowest pressure on record in the Gulf of Mexico. Maximum winds at this time were 150 kn. On the 29th and 30th Anita's central pressure dropped at a rate of 0.5 mb/hr and increased to a rate of 2.0 mb/hr on the 31st and September 1 (fig. 52).

Landfall occurred at 1100 September 2 along a sparsely populated region of Mexico about 80 mi north

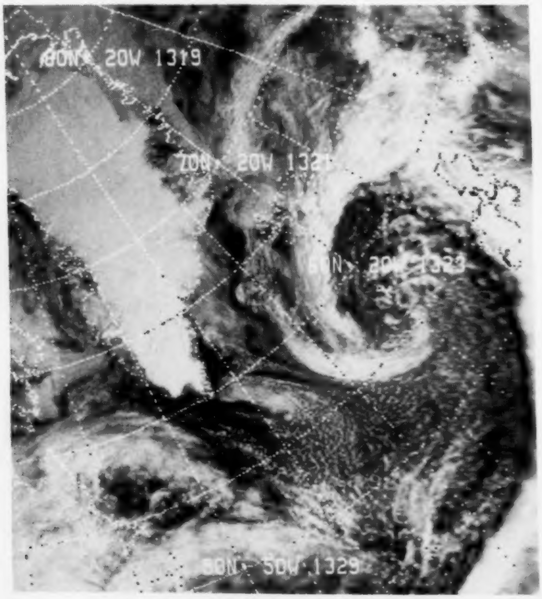


Figure 51.--The C.P. TRADER was sailing south of an area of maximum vorticity as indicated by the curved cloud mass.

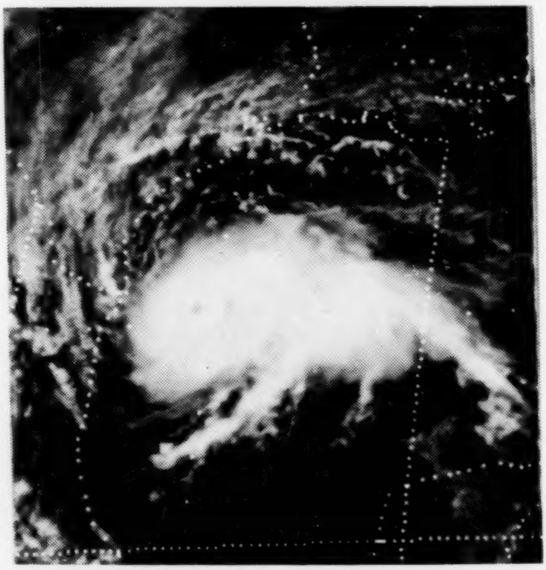


Figure 52.--Anita, a blockbuster of a hurricane, gathers strength as she prepares to strike the mainland just south of the border.

of Tampico (145 mi south of Brownsville). The nearest population center in Anita's path was the inland village of Soto La Marina, 165 mi south of the border and 24 mi from the coast.

Sea surface temperatures over the Gulf of Mexico were near normal, about 29°C, well above the threshold value considered necessary for tropical storm genesis. On August 25, several days prior to Anita's formation, the NOAA ship RESEARCHER found an eddy in the sea surface temperature field in the vicinity of Anita's path. This eddy was as much as 1°C warmer than the surrounding waters. This is considered to be part of a unique data set that may provide insight into the intensification mechanism.

The only report of casualties in connection with Anita is a UPI story stating that: "Mexico City newspapers reported floods and landslides killed 10 persons in the area from La Pesca inland to Ciudad Victoria." Property damage in the United States was minimal and mainly limited to minor flooding of low-lying areas. The portion of the Mexican coast that was most affected by the hurricane is sparsely settled and no dollar damage estimates are available. All that can be said at this time is that extensive property losses were sustained by inhabitants of fishing villages along the coast and agricultural losses by small farming communities in Anita's path. Rainfall in the United States was generally slight, with 2 in reported in southern Texas, which was considered beneficial to agriculture. Mexican rainfall reports are conflicting, but one report of a 6-hr total of 17.52 in was received from Soto La Marina.

The threatening nature of this very intense storm resulted in considerable evacuation of coastal areas. The oil industry alone evacuated more than 7,000 workers from offshore drilling platforms in the Gulf of Mexico. Nearly 10,000 people were ordered inland from southeast Louisiana coastal communities threatened by high tides. Along the upper coast of Texas as many as 35,000 people were temporarily relocated to higher ground. Estimates range up to 10,000 residents and vacationers fleeing inland from southern Texas coastal islands. Finally, the New York Times reported that the Mexican Army evacuated 35,000 people from villages along a 240-mi stretch of coast from Tampico north to the United States border.

Maximum tides along the Texas and Louisiana coasts were 3 to 5 ft above normal. Maximum sustained winds of 55 kn in the United States were reported from the Coast Guard Station on South Padre Island, Tex. An insurance company with instrumentation on the Bahia Mar condominium reported a 5-min average wind of 81 kn.

Casualties--On the 5th the U. S. Navy tanker POTOMAC had a 10- by 12-ft hole punched in her fuel tank by ice in Melville Bay and spilled approximately 3,000 barrels of oil. A search was made in the vicinity of St. Pierre and Miquelon for the Canadian trawler CAPE ROYAL, which was hampered by fog and overdue. The 13,600-ton Hungarian freighter ADY and the 7,554-ton Singapore-flag NORDWOGE collided in the Scheldt River in dense fog on the 21st. The ships stuck together and were towed to Schaar Van de Noord, where torches were used to separate them.

ROUGH LOG, SEPTEMBER 1977--This was the month of the "Great Lakes Trail." The favorite path for storms was almost due east across the Lakes. An isolated storm moved across the southeastern United States, and several storms moved across Canada, but there was no other concentration. The Great Lakes track was joined near Nova Scotia by a secondary track off the northeast coast of the United States. Near this point the track forked, with one path to the northeast toward Iceland and the other path eastward to later turn northeastward.

The gross pressure pattern matched the climatic pattern in the location and pressures of the major pressure centers. The Icelandic Low at 1004 mb was midway between Kap Farvel and Iceland near 62°N, 30°W. The Azores High was 1022 mb and centered near 33°N, 27°W. It extended into western Europe with two other centers, a 1022-mb center off Portugal and a 1024 mb near Le Havre. There were other low centers over the Greenland and Kara Seas.

The pressures over the Mid-Atlantic and major shipping lanes were near normal. The two major anomaly centers were a positive 9 mb over Hudson Strait and another positive 9 mb over the English Channel. These positive anomalies and the pressures associated with them give an indication of why the storm tracks followed the paths they did.

The upper air pattern at 700 mb was near the climatic normal, except for the location of the major troughs. The trough that is normally over the U. S. East Coast was displaced eastward over the water. The trough that normally parallels longitude 10°W was displaced westward to approximately 25°W, and a ridge line paralleled longitude 5°W. The major anomalies were both positive and matched the location of their surface counterparts.

There were three tropical cyclones--hurricanes Babe, Clara, and Dorothy.

Extratropical Cyclones--This storm was over Hudson Bay on the 1st. At midday on the 2d, it was 990 mb over the Labrador Sea where the N. B. MCLEAN, east of Hopedale, braved 35 kn, near-freezing gales and 12-ft seas. As the storm passed north of OWS Charlie on the 3d, she measured 40 kn with 16-ft seas. A ship a few miles north of Charlie registered 48-kn winds and 23-ft seas. In 24 hr the central pressure of the storm dropped 30 mb to 960 mb at 1200 on the 3d. Many ships were reporting gales of 35 to 45 kn. The OAKWORTH at 55°N, 35°W, reported the highest waves of 26 ft.

At 0000 on the 4th, the 960-mb storm was near 61°N, 30°W. The NAWORTH (59°N, 30°W), the ATLANTIC CONVEYOR (56°N, 27°W), and another ship near 57°N, 35°W, all reported 55-kn winds. The highest seas were 30 ft by the NAWORTH. The UNIWERS WROCLAWSKI fought 60-kn winds near 54°N, 35°W, on the 4th at 1200. OWS Lima was tossed by 50-kn winds and 28-ft seas. Waves up to 25 ft were common (fig. 53). At 1800 Lima reported swells of 41 ft.

On the 5th the LOW turned northward and moved over the Faeroe Islands. It was still causing 20-ft waves over the northern shipping lanes. By the 7th the center was over the Barents Sea.

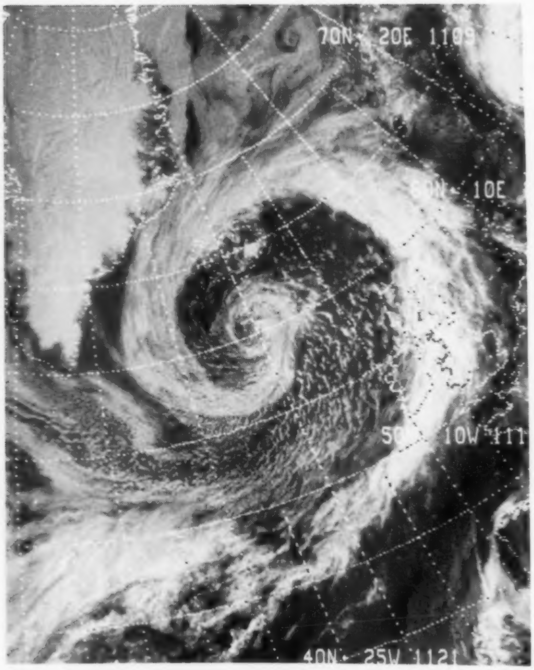


Figure 53.--This large, deep storm extended its influence from the Labrador Sea to the North Sea and from latitudes 45°N to 70°N.

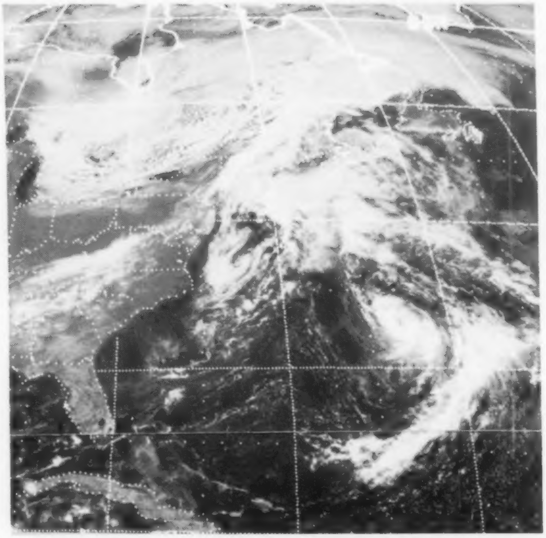


Figure 54.--This was a stormy day. The severe LOW was over Canada causing high winds and waves on the Great Lakes. There is another extratropical LOW along the Delaware coast and tropical storm Clara near Bermuda.

On the 4th a front stretched eastward from the Carolina coast. Minor waves were rippling along the front, and the BLUE BIRD reported a waterspout off the coast at 1300. Severe thunderstorms were reported through the morning. Heavy fog closed the Soo Locks for a time during early morning of the 8th.

Several LOW centers combined near the end of Lake Superior on the 1200 analysis of the 4th. The storm moved across the Lakes bringing rain and thunderstorms to the area. On the 6th the LOW nearly dissipated as it traversed the St. Lawrence River Valley, but it gained strength on the 7th near the coast. At 1200 on the 8th the storm was centered near 58°N, 50°W. A Brazilian-registered ship near 53°N, 46°W, was tossed by 18-ft seas. The C. P. DISCOVERER (53°N, 59°W) was just east of the point of occlusion at 1800 with high winds. Three ships off of Belle Isle reported 50- to 56-kn winds. The SUGAR PRODUCER found 40-kn winds with 30-ft swells about 300 mi directly below the storm center on the 9th. On the 10th the storm stalled southwest of Iceland and disappeared on the 11th.

This storm formed over the high plains and mountains of northern Wyoming and southern Montana on the 8th. On the 9th it moved from Minnesota into southern Canada, producing thunderstorms over Lake Superior. By 0000 on the 10th, the center was 991 mb north of Sault Ste. Marie. A boat on Lake Superior measured 55-kn winds and waves of 15 ft. The island of Isle Royal also measured 55-kn winds. Storm and gale warnings were posted for Lakes Superior and Huron. Later on the 10th, winds of 50 kn were reported on Lake Ontario (fig. 54). At 1800 two boats on Lake Huron reported 60-kn winds with 8-ft seas. This LOW disobeyed the normal rule and weakened as it approached and moved off the coast. It disappeared west of Kap Farvel on the 12th.

A front over the middle Atlantic was following the Azores High as it retreated eastward toward the continent. Another High was following out of Canada and New England. Several waves had moved northeastward along the front during the previous days. The 1200 chart of the 11th (fig. 55) showed a more stable LOW with a larger circulation near 45°N, 29°W. The AMERICAN ALLIANCE was north of the center near 48°N, 30°W, with 35-kn gales and 20-ft seas and swells. A ship identified as PESD at 47°N, 32°W, had roaring 60-kn winds from the north and 36-ft swells. At 1800 the PESD and PJCM reported 45-kn gales and 26-ft swells. As the LOW was moving southward, it was squeezed between three high-pressure cells. On the 12th a ship south of the center encountered swells of 18 ft. Later that day the 1004-mb LOW stalled near 40°N, 30°W. On the 14th the storm was absorbed by a new system moving in from the west.

This was a north latitude storm. It formed off Scoresby Sound on the 13th. A fishing vessel reported 45-kn winds near the southeastern coast of Iceland. By 1200 a half-dozen ships reported winds of 35 to 40 kn in the vicinity of Iceland. The LOW was 975 mb at 0000 on the 14th. The DISCOVERY was near the Outer Hebrides with 40-kn winds and 28-ft seas. Two land stations on the coast of Norway reported 45-kn winds

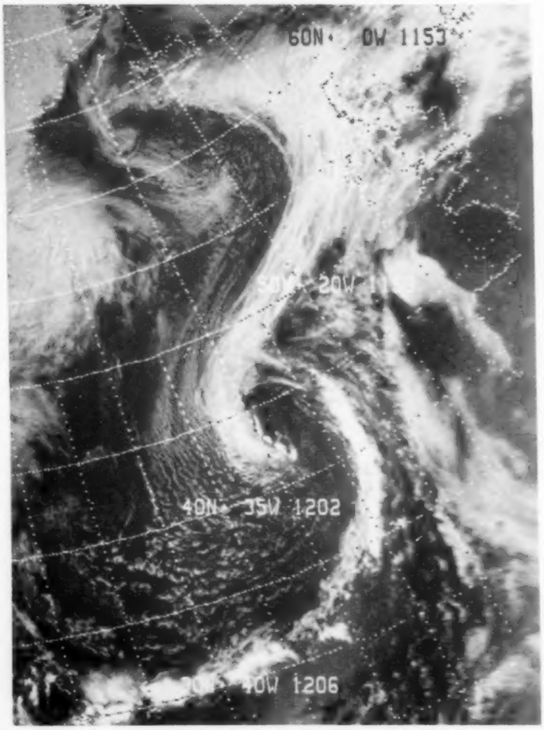


Figure 55.--It can be seen readily from this satellite image why this type meteorological formation is called a wave. There is a line of very heavy thunder storms between 42° and 45°N and 28° and 30°W.

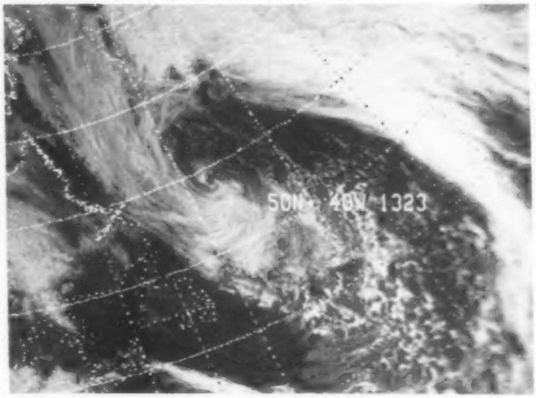


Figure 56.--Strong winds and high waves were reported both west and south of the storm's center.

from the south. Ships in the Norwegian Sea were fighting 35- to 40-kn winds, and the seas were generally 10 to 20 ft. A ship near Spitsbergen had 48-kn winds. On the 15th a ship that may have been OWS Mike measured 40-kn winds and 20-ft seas. Later in the day the LOW suddenly dissipated, and a LOW near Leningrad became the major circulation center.

Cyclogenesis occurred over Lake Erie on the 13th. The storm developed rapidly and was a 992-mb LOW as it moved over Nova Scotia on the 15th. It brought rain and strong winds especially in the northern sector as it moved eastward. The Magdalen Islands in the Gulf of St. Lawrence reported 40-kn winds. The ARCTIC TROLL was hit by 50-kn and higher winds at 0000 and 1200 with 20-ft waves at 1200 near 42°N, 63°W. Gales of 35 to 45 kn and seas up to 15 ft continued in the southern half of the storm. The PRINCESS OF TASMANIA reported 55-kn northwesterly winds just off Hamilton Inlet on the 17th. Two ships in the vicinity of 53°N, 50°W, were battered by 20- and 23-ft swells. The HASTINGS (52°N, 50°W) suffered heavy rain, 52-kn winds, and 20-ft waves (fig. 56).

On the 17th and 18th the storm center looped counterclockwise near 56°N, 46°W, with the pressure slowly rising. On the 19th the LOW was only an area

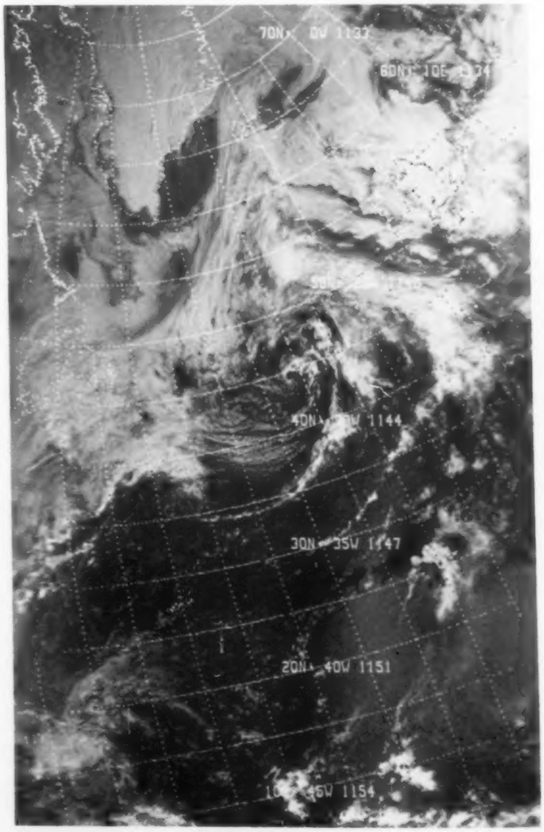


Figure 57.--A larger area of cumulus and stratocumulus clouds is associated with the HIGH over Scotland than with the LOW. The lower right of the picture shows either high, thin cirrus clouds or high-altitude dust.

of weak gradient south of Kap Farvel.

The ocean north of latitude 35°N was very diffuse with multiple LOW and HIGH centers. The Azores High and a high-pressure center north of Scotland were the most prominent features. At 0600 on the 21st, a new center was analyzed near 49°N, 43°W. By 1200 it was a prominent feature with several 40-kn wind reports. At 1200 on the 22d, the 990-mb storm was near 45°N, 30°W (fig. 57). The two HIGHs were weakening and retreating. Several ships reported gales or stronger. Among these were the IRISH OAK (40°N, 31°W) with 44 kn and 20-ft seas and the CITY OF GUILDFORD (40°N, 36°W) with 37 kn and 21-ft waves.

On the 23d the storm was moving northward at 980 mb. Two U. S. S. R. ships both east and west of the center found winds over 40 kn at 1200. The UUWI had 25-ft seas on the west side of the center near 52°N, 29°W, and the RIGG had 21-ft swells on the east side near 53°N, 13°W. At 1800 the RIGG had 55-kn winds and 18-ft swells. The LOW disappeared south of Iceland on the 25th.

This LOW developed east of one that had moved out of Quebec and into the Gulf of St. Lawrence on the 28th, near 52°N, 51°W. South of the center the ATLANTIC CAUSEWAY was sailing with 20-ft swells. The storm was caught under the center of very strong upper air zonal flow, especially for this time of year. It raced northeastward and at 0000 on the 29th was at 59°N, 34°W. Ocean Weather Station Charlie measured 35-kn winds, 20-ft seas, and 23-ft swells. Lima also had 35-kn winds, but the seas had built to only 12 ft. Twelve hours later she had 40-kn winds and 20-ft swells. Gales continued in the southern part of the storm as it was absorbed by another over the Norwegian Sea. The combined storm moved over Scandinavia.

Tropical Cyclones--Babe formed from the interaction between an African wave which reached the Gulf of Mexico on the 2d and a cold upper low just south of Apalachicola, Fla. On September 2, widespread convective cloudiness covered Florida and adjacent waters of the Gulf of Mexico and the Atlantic, but there was little evidence of organization in the cloud pattern. By the 3d the 200-mb LOW had moved southwestward to the middle Gulf of Mexico, and westerly surface winds at data buoy EB44 confirmed that a surface LOW had formed in the east-central Gulf of Mexico. It was also evident that the system was essentially cold core. Convection was not concentrated near the surface low center, but rather in a band extending from the central Gulf of Mexico north-northeastward to the mouth of the Mississippi River, then eastward to just off the coasts of Mississippi, Alabama, and the Florida Panhandle. Gale-force winds in this west-east band of convection led to posting of gale warnings from Morgan City, La., to Pensacola, Fla., at 1600.

By early morning on the 4th, the west-east band of strong convection had moved inland and weakened. Interest then shifted southwestward into the central Gulf of Mexico, where reconnaissance reports and satellite imagery showed that the strongest winds were drawing in closer to the vortex. Meanwhile, the 200-mb LOW continued to move southwestward into the southwestern Gulf of Mexico, and the high-level flow

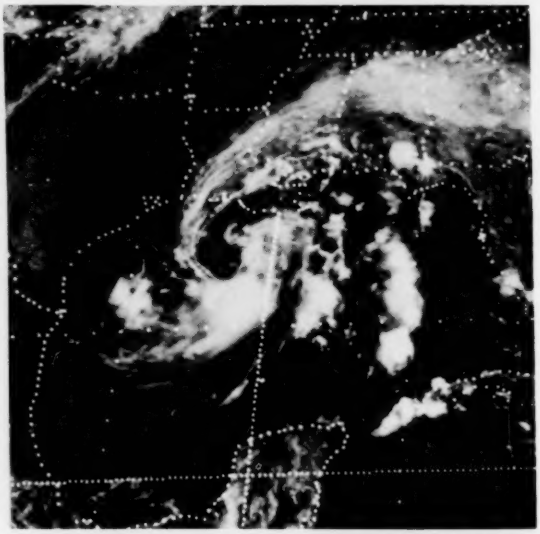


Figure 58.--Babe as she appeared at noon on the 4th, when 70-kn squalls were reported.

over the surface system became increasingly anticyclonic. The transition from a subtropical to a tropical storm was completed by midday.

A northward movement was underway by the afternoon of the 4th. Air Force reconnaissance reported a surface wind of 70 kn at 1903, some 55 mi southeast of the storm's center (fig. 58). It is evident from postanalysis that these winds were associated with a narrow band of strong convection well removed from the center; they were transitory and were not representative of the strength of the system. The same report showed the lowest pressure to be 1000 mb, well above that generally required for sustained winds of hurricane strength with the existing peripheral pressures.

The storm center was only 70 mi from the Louisiana coast by 0000 on the 5th. Hurricane strength was reached at about 0600, when Air Force reconnaissance reported a central pressure of 995 mb. Maximum sustained winds over water are not believed to have exceeded 65 kn, and it is doubtful that any hurricane-force winds occurred over land. The strength of the system decreased rapidly after landfall, and it was reduced to a depression by midafternoon. Following an initial jog to the left after the center crossed the coast, the depression moved essentially northeastward across southern Mississippi and central Alabama, then east-northeastward across northern Georgia.

The highest wind on land was the Coast Guard reading of a 46-kn gust at Grand Isle, La. The highest sustained wind reported was 40 kn at Boothville, La. No significant wind damage was reported near the coast, except for some scattered tornado damage. A number of tornadoes occurred after the storm moved inland. On September 5, six were reported in southeastern Louisiana and three in southern Mississippi. One or possibly more tornadoes occurred on the 6th near Tuscaloosa, Ala., as the depression approached that area, and there was a report of a possible tornado

in northwestern Georgia on the afternoon of the 7th. Tornado damage consisted of an unroofed school, several unroofed houses and destroyed barns, and a number of uprooted trees.

Highest tides were up to 6 ft above mean sea level or 4 to 5 ft above normal in southeastern Louisiana and up to 3 ft above normal as far east as Mobile, Ala. There was flooding of streets and highways in southeastern Louisiana, causing some property damage. Flash floods created by heavy rains accompanied the remnants of Babe through the southeastern States, beginning in southeastern Louisiana and southern Mississippi on September 5 and 6, spreading into northern and central Alabama and eastern Tennessee on the 6th and 7th, and into the mountains of the Carolinas and southwestern Virginia on the 7th and 8th. As much as 6 to 7 in of rain fell during the 24-hr period in the mountains of eastern Tennessee and the Carolinas, and up to 4 in elsewhere in the area of flash flooding.

Preliminary estimates of damage caused by Babe are about $10 million, mostly in southern Louisiana. There was some damage to crops, principally sugarcane, caused by heavy rain and wind. No serious injuries or fatalities were reported.

Hurricane Clara had an unusual origin. The convective cloud mass from which it developed was a spiral band containing gale-force winds which was associated with the initial development of Babe. As the band moved inland into southeastern Georgia, a weak circulation developed at middle tropospheric levels late on September 4. By 1200 on the 5th, Charleston, S.C., had a 24-hr pressure fall of 4 mb and a west surface wind, indicating the formation of a weak depression just north of the city. The depression drifted east-northeastward during the next 36 hr, slowly becoming better organized.

The depression was located a short distance south of Cape Hatteras on the evening of the 6th, when it accelerated towards the east-northeast and began strengthening. Satellite pictures and ship reports at 1200 on the 7th located the depression about 75 mi southeast of Cape Hatteras, with winds of 30 kn. Air Force reconnaissance reports late that afternoon confirmed a continued strengthening trend (fig. 59). Clara reached tropical storm strength by 0000 on the 8th, when the center was about 200 mi east of Cape Hatteras. The central pressure continued dropping about 1 mb per hr for the next 12 hr. The lowest sea level pressure of 993 mb and maximum sustained winds of 65 kn were reached on the morning of the 8th. The central pressure began to rise as the trough of low pressure which had accelerated Clara left it behind. However, reconnaissance aircraft reported hurricane-force winds more than 12 hr after the lowest pressure was reached.

Clara turned toward the southeast and made a tight loop over a period of 36 hr before accelerating again towards the northeast and becoming absorbed in an extratropical low-pressure system several hundred miles northeast of Bermuda on the 11th.

Hurricane Dorothy emerged from a tropical disturbance that moved off the northwestern African coast on September 15. The system moved westward at 15 to 20 kn and began to show better cloud organization on the 20th. As it approached the Lesser Antilles, reconnaissance aircraft confirmed that it was a strong tropical wave. The wave moved through the northern Windward and southern Leeward Islands on the 21st accompanied by heavy rains and strong gusty winds. Gusts of 60 kn were reported at exposed locations on the islands of Guadeloupe and Martinique. Several islands reported rainfall of 5 to 8 in with flash flooding.

Prior to arrival of the tropical wave into the eastern Caribbean a large ridge of high pressure had persisted for several days over the Gulf of Mexico and the western Caribbean with a weak stationary frontal trough off the southeastern coast of the United States. Under this pattern the disturbed weather area associated with the wave began moving northward through the eastern Bahamas at 10 kn on the 24th and 25th.

On the afternoon of the 25th a weak low-pressure system began developing in the disturbed weather area

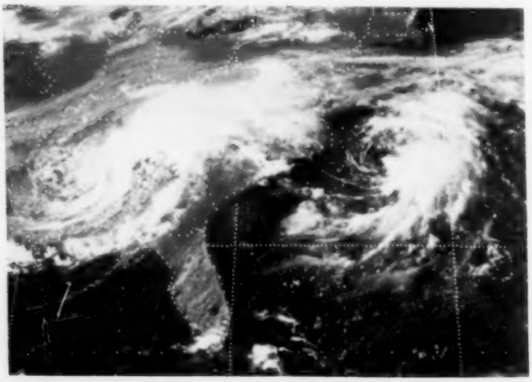


Figure 59.--Hurricane Clara was southeast of Cape Hatteras at 1800 on the 7th, with the remnants of hurricane Babe over Mississippi and Alabama.

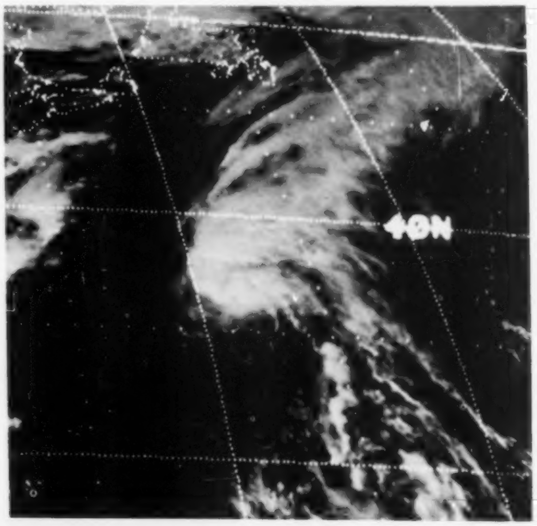


Figure 60.--Dorothy was at maximum strength on the 28th as she moved into the major shipping lanes.

north of the Bahamas and gradually organized into the fifth tropical depression of the season on the 26th. The depression was moving northeastward at 10 to 15 kn, and by the morning of the 27th reconnaissance aircraft indicated that it had strengthened to a tropical storm with winds of 45 kn and lowest pressure of 1000 mb. Dorothy moved east-northeastward at 15 kn and attained hurricane strength on the morning of the 28th. Thereafter, the hurricane turned toward the northeast and accelerated to 20 kn. Dorothy gradually lost tropical characteristics as she moved rapidly northeastward just east of Cape Race, Newfoundland, on the evening of the 29th and was absorbed by a frontal low-pressure system over the cold water of the North Atlantic the following day.

Dorothy attained maximum strength on the evening of September 28 with highest winds and lowest pressure estimated at 75 kn and 980 mb, respectively (fig. 60). She was mainly a threat to shipping. Both Bermuda and eastern Newfoundland were on the weak side of the storm with no damage reported. No reports have been received from the southern Leeward or northern Windward islands concerning damage from flash floods and strong winds.

Casualties--There were no notices of weather-related casualties this month.

Rough Log, North Pacific Weather

August and September 1977

ROUGH LOG, AUGUST 1977--There appeared to be very little rhyme or reason to the storm paths this month. The only area where there was a semblance of concentration to be referred to as a path was from interior Siberia into the East Siberian Sea. Cyclones in the vicinity of Japan tended to move northward. Storms over the central ocean and Bering Sea each had their own orientation. No storm center disturbed the northern part of the Gulf of Alaska. They dissipated or turned northwestward prior to entering the Gulf. Climatology indicates three primary tracks--from the Sea of Okhotsk into the Bering Sea, Japan into the Bering Sea, and the north central ocean into the Gulf of Alaska.

Only the basic circulation centers of the mean sea-level pressure analysis matched climatology. The 1007-mb Aleutian Low was centered east of Kamchatka near its 1008-mb climatic counterpart. The 1023-mb Pacific High was near 34°N, 143°W, about 500 mi southeast of its 1024-mb climatic position. A secondary 1008-mb LOW was centered over Unimak Island. This produced a deep trough in the center of the Pacific High giving it a waterwing rather than an egg-shaped configuration. This resulted in a large minus 9-mb anomaly center over the central ocean. A sharp ridge extended from the center of the HIGH to the southeastern coast of Alaska, giving an indication of why few storms penetrated that area. The Pacific High also extended further west than normal, resulting in an area of positive anomaly 20° longitude wide southeast of Kamchatka. There was an anomalous 1005-mb LOW east of Kyushu with a resulting 5-mb anomaly center.

The upper air pattern also differed radically from climatology. The LOW at 700 mb was centered near the Fox Islands (54°N, 170°W). Again, a sharp trough dipped into the HIGH dividing it into two centers, with a sharp ridge off the Canadian west coast extending well into the Beaufort Sea.

There were two tropical cyclones, hurricane Doreen over the eastern Pacific and tropical storm Amy over the western Pacific.

Extratropical Cyclones--During the first half of the month, a high-pressure cell was well entrenched over the central ocean near 40°N, 180°. It began at 1028 mb and built to a high of 1032 mb by the end of the first week (fig. 61). By the middle of the month, it was 1025 mb near 35°N, 165°E, and breaking down. LOWs that approached from south and west were diverted northward and/or dissipated. One of these was the extratropical remains of tropical storm Wanda. This relatively weak LOW (about 998 mb) had persisted near 33°N, 150°E, for over a day. On the 5th a 997-mb LOW crossed Japan (fig. 62). The northern part of Honshu was flooded by heavy rains of up to 1 ft. Seven persons were killed and four missing after flash floods. About 5,000 families had to evacuate their homes. Roads were damaged, bridges washed away, and landslides contributed to the misery. The PLUTO at 43°N, 160°E, suffered 44-kn gales. On the first chart of the 7th the two centers had combined into one 996-mb center. This center rolled northward along the 152°E meridian. The gradient between the two centers tightened, and with the steady southerly winds and long fetch, the OJI MARU was hit by 25-ft swells

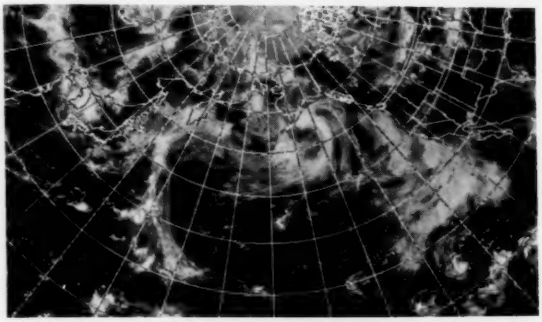


Figure 61.--Anticyclonic circulation from the large HIGH stretched from 160°E to the west coast of North America. A LOW had moved along the Aleutians, but a ridge off the West Coast impeded its progress and produced a broad expanse of stratus and fog.

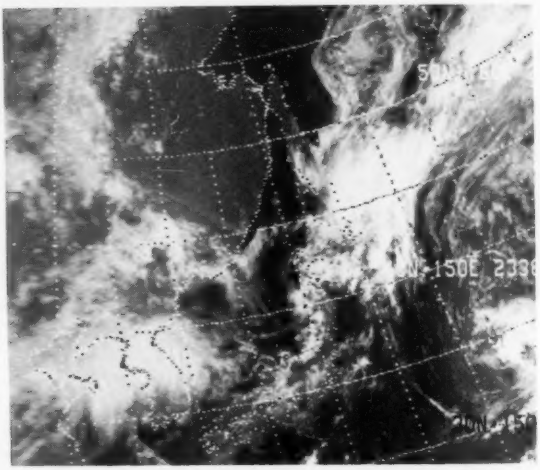


Figure 62.--At 0900 local time on the 6th, rain clouds still cover northern Japan. Extratropical storm Wanda is centered near 34°N, 154°E.

near 47°N, 166°E, at 1200.

A frontal wave developed over China and moved over the Sea of Japan on the 7th. On the 0000 chart of the 9th it was 990 mb over Hokkaido. At that time the MEDARIANA (35°N, 142°E) was blasted by 60-kn southwesterly winds just east of the cold front. The PRESIDENT PIERCE (40°N, 147°E) had 45-kn gales, and several other ships reported lighter gales in the area. The HIGH over the central ocean turned the storm northward over the Sea of Okhotsk on the 10th.

This was strictly a Bering Sea storm. The center looped counterclockwise over the center of the Sea. The LOW formed at a point of occlusion near 56°N, 171°E, on the 14th. The LOW moved as far east as the 180° meridian, where it paused for 24 hr before turning back westward on the 16th. At 0000 the center was 993 mb. The ASIA BOTAN, a good reporter, was headed into 50-kn westerly winds about 300 mi south of the center. On the 18th the LOW dissipated.

The persistent HIGH was breaking down by the middle of the month, and a wave formed on a weak front near 45°N, 160°E, on the 18th. It raced east-southeastward under zonal flow. Ships east and west of the center were reporting moderate to heavy rain. The LOW passed north of the ORIENTAL EDUCATOR treating her to 35-kn gales.

On the 19th the LOW started deepening as it turned northeastward. On the 20th, the LOW was 986 mb near 46°N, 167°W. The HOLLAND MARU was less than 200 mi southwest of the center with 40-kn winds and waves of 12 ft. On the 21st, the OJI MARU had 43-kn northeasterlies. The AMSTELHOF was at least 400 mi south of the LOW with 20-ft swells. The LOW passed very close to two ships at 1200 on the 21st. The LOW was analyzed as 981 mb, and the ships registered 985 mb on their barometers (fig. 63). The KOULOUNDA had 50-kn winds with 20-ft seas, and the UZBEKISTAN had 52 kn with no seas indicated.

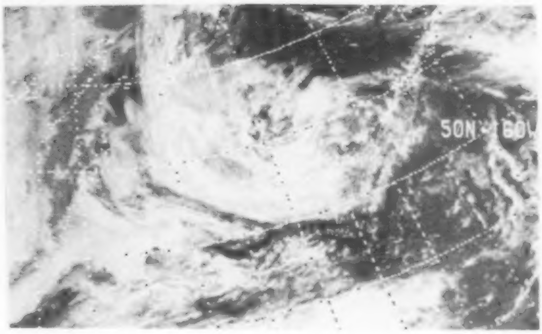


Figure 63.--Both the high-level and surface circulation centers can be seen in this image. The cold high-level center is near 55°N, 178°W, and the surface center is near 53°N, 174°W.

On the 21st the LOW started turning westward, and a frontal wave moved eastward south of the LOW. The LOW continued to circle southward and completed the loop by the 25th and was moving northeastward again. During that time the LOW filled and weakened with a much smaller circulation. The JAPAN RAINBOW was southeast of the LOW that moved around the periphery with 40-kn gales and 34-ft swells. The original LOW continued northeastward to dissipate near Kodiak Island on the 27th.

A frontal wave formed off Japan on the 19th and split into two LOWs on the 21st. The eastern one survived. On the 22d the PICA was north of the center and sailing into 45-kn easterly winds. Along the warm front a ship reported 16-ft seas and 20-ft swells. As this LOW passed south of the one described above, several ships reported gales. It was with this LOW that the JAPAN RAINBOW found the 34-ft swells on the 24th. The lowest pressure was 990 mb on the 24th (fig. 64). The JAPAN RAINBOW was headed eastward along with the storm and at 0000 on the 25th had 40-kn winds with the swells remaining at 34 ft. Later in the day the LOW disappeared.

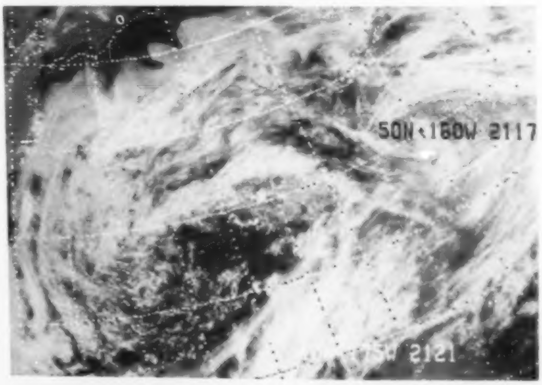


Figure 64.--The remnants of the older storm can be seen near 48°N, 180°. The new storm is near 50°N, 160°W. The JAPAN RAINBOW was about 400 mi southeast of the center.

This frontal wave started on the 21st south of Japan on a front that stretched into former tropical storm Amy. On the 22d it was labeled a tropical depression, but on the 23d a cold front developed. The JLJL was near the front at 30°N, 141°E, with 40-kn winds and 15-ft waves. On the 24th the INACHUS STAR was 400 mi west of the 988-mb center with 40-kn winds and 23-ft swells. On the 25th the swells were 25 ft, but the winds had decreased. The INACHUS STAR was following the storm, and on the 26th the swell had increased to 26 ft. The UNIQUE FORTUNE was also west of the 992-mb center with 20-ft swells.

The LOW had shifted to a southeasterly direction with the INACHUS STAR still calling the swell waves 25 ft at 1200. By the 27th the LOW had turned southward and then westward. It had weakened considerably, and there were three centers in a weak pressure area. Late on the 28th, no circulation center could be found.

Tropical Cyclones, Eastern Pacific--Doreen was the second tropical cyclone within a year to bring heavy rains to southern California. She began as a tropical disturbance 100 mi west of Acapulco, Mexico, at 0000 on the 11th. Ship reports along the Mexican coast helped to locate the disturbance with those south of Acapulco reporting southeasterly winds and those north of Acapulco reporting northwesterly winds. Drifting west at 6 kn, the disturbance was upgraded to a tropical depression at 0000 on the 13th about 400 mi west of Acapulco. The cyclone then turned northwestward and began to slowly intensify over 82°F water. By 1800 winds near the center had increased to 45 kn.

Twenty-four hours later Air Force reconnaissance had located the center of Doreen 160 mi south of the tip of Baja California. Based on extrapolated sea-level pressure (979 mb), the storm was upgraded to a hurricane with 65-kn winds near the center. The eye, open to the southwest, was 15 mi in diameter.

Turning toward the north-northwest and increasing her speed to 9 kn, Doreen passed 30 mi west of the tip of Baja California early on the 15th. She then turned northwestward and, moving at 18 kn, touched onshore briefly near San Carlos on the west coast of southern Baja. Doreen moved northwestward over cooler 72°F water and weakened. By the 16th winds near the center had decreased to 50 kn, and the hurricane was downgraded to a tropical storm near 26.4°N, 113.2°W. Drifting onshore again, Doreen moved to the tip of the Point Eugenia Peninsula, then offshore over the Bay of Sebastian Vizcaino. Winds near the center had decreased to 35 kn over water that was now near 68°F.

Winds continued to decrease as Doreen drifted toward the southern California coast. By 0600 on the 17th, with winds near 30 kn, she was downgraded to a tropical depression 130 mi south of San Diego. With satellite imagery showing weak low-level cyclonic circulation, the final advisory was issued at 1800 with the center 25 mi north-northwest of San Clemente Island off the southern California coast. Remnants of Doreen then drifted slowly northeastward across southern California.

While Doreen was off the central Mexican coast and still south of Baja California, another disturbance developing near 15°N, 119°W, began to drift eastward into the cyclonic flow associated with Doreen. Ships within 300 mi of this new disturbance reported moderate to heavy rain. As Doreen moved northward along the Baja California coast, this moisture was carried northward around Doreen and into southern California. This moist tropical air began to enhance shower and thundershower activity over the southern California desert areas on the 15th. Flash flood watches and warnings already in effect for heavy thundershowers over the Colorado River Valley and eastern desert areas were extended with heavy rain warnings to most of southern California by the 16th (fig. 65).

Figure 65.--At noon local time on the 16th, Doreen is over Cedros Island. Clouds from the disturbance can be seen feeding additional moisture northward.

Rain moving northward with Doreen reached San Diego early on August 16, spreading northward to the Los Angeles basin and Mojave Desert by afternoon and Owens Valley and southern San Joaquin Valley by evening. On the coast rain spread as far north as Santa Barbara by early the next morning. Rain continued over southern California through late evening on the 17th, and a few lingering showers remained in the Los Angeles area until late the following morning. An average of 2 to 4 in of rain fell over the low-lying areas of southern California during the 3-day period, and as much as 7.5 in in the higher mountains. A total

Figure 66.--Flood waters from Doreen carried rocks and mud through the door of this home in Borrego Springs in southern California. Los Angeles Times Photo.

of 2.13 in of rain fell at San Diego airport, 3.78 in at Calexico, 3.87 in at Imperial, 2.47 in at Los Angeles airport, 3.14 in at Santa Monica, 2.61 in at Mt. Wilson near Los Angeles, and 7.45 in at Mt. San Jacinto west of Palm Springs. Unusually heavy rain fell at Mitchell Caverns 60 mi west of Needles, where 6 in was reported on the 17th.

There were no deaths in the United States directly attributable to Doreen, but five deaths were indirectly attributed to the heavy rains and flooding. Damage was extensive, particularly to agricultural interests in the Imperial and San Diego counties. Losses are estimated in excess of $25 million. Flood waters destroyed 325 homes and businesses (fig. 66) in the southern desert areas, and several people were evacuated from low-lying areas. The small desert town of Ocotillo was flooded again as it had been during hurricane Kathleen in September 1976. Buses sent to evacuate people from Ocotillo returned empty, however, when the townspeople declined to leave their small community. Interstate Highway 8 at Myers Creek, west of Ocotillo, was washed out again as it had been during Kathleen. Although floodwaters were less than with Kathleen, boulders the size of small cars were observed moving down Interstate Highway 15 between Los Angeles and Las Vegas, and floodwaters carried away two of the four lanes.

Tropical Cyclones, Western Pacific--Amy, the region's only tropical cyclone this month, formed in the Luzon Strait on the 20th. Moving westward, she quickly reached tropical storm strength later in the day. Winds near the center climbed to just 35 kn and then slackened early the next day. As a depression, Amy moved northeastward past the east coast of Taiwan on the 22d. Amy reintensified in the East China Sea. On the 24th she moved across Kyushu, near Nagasaki. Winds of 50 kn blew around her 985-mb center. Heavy downpours lashed western Japan with total storm amounts of up to 20 in, as Amy fell to depression strength and stagnated off Shikoku.

Casualties--The barge MLC 25 in tow of the tug PETER W. bound for Dutch Harbor from Seattle encountered heavy weather 2 days out of Sand Point, Alaska. The cargo of construction material was damaged. The 6,460-ton Iranian ARYA OMID enroute to Yokohama from the Persian Gulf reported heavy weather damage.

ROUGH LOG, SEPTEMBER 1977--There was very little correlation between the actual storm tracks this month and climatology. In the simplest analysis, the tracks were shifted many degrees of longitude to the west. The majority of the persistent cyclones were over or just off the Asian mainland. A fairly well-traveled path started over the western Aleutian Islands and through the Bering Sea to Alaska. Four storms wandered around the central ocean. An average of one cyclone a week approached the west coast of Canada and the United States, but only two managed to cross the mountains.

The pressure centers were also west of their climatological positions and more intense. The most obvious departure from climatology was the lack of an Aleutian Low, which is normally 1006 mb and centered over Bristol Bay. A secondary 1010-mb LOW over the Sea of Okhotsk was matched by one of 1005 mb, and another 1005-mb LOW was centered to the northeast over Siberia. The Pacific High was 1025 mb near 41°N, 158°W, 4 mb higher and about 750 mi northwest of its normal position. It was much broader to the north and west. This produced a large area of positive anomaly with a plus 11-mb center that covered most of the ocean north of 30°N. There were two negative anomaly centers of 7 and 8 mb over western Siberia near the low-pressure centers.

The upper air pattern at the 700-mb surface differed radically from climatology over the northern latitudes. The major trough that is usually over the Bering Sea appeared to be shifted westward to reinforce the normal long-wave trough over the east coast of Asia. There was a short-wave trough over

western Alaska. There was also a pronounced trough off the west coast of the United States extending northward over the Canadian coast, which is normally dominated by a ridge. The Pacific High was near normal. The major anomaly was a plus 115 m, centered south of Unimak Island and reflecting the absence of the Aleutian trough. Negative anomaly centers over Siberia and Vancouver Island reflected the anomalous troughs.

There were eight tropical cyclones over the North Pacific this month. The western ocean had five, two typhoons and three tropical storms. The eastern ocean hosted two tropical storms and one hurricane.

Extratropical Cyclones--The first half of the month was relatively quiet, except for typhoon Babe over the Philippine Sea. The Pacific High was well entrenched over the central ocean. Extratropical LOWs tracked northeastward along the Asian coast.

The usual heat LOW was stationary over the Imperial Valley of southern California. On the 8th a new center developed on the eastern side of the Pacific High, tightening the gradient between the two centers along the U. S. West Coast. Late on the 9th, two ships reported winds over 40 kn. The KBCF near Cape Mendocino had 45-kn northerly winds with 36-ft swells. The CHEVRON EINDHOVEN near Cape Blanco reported 43-kn winds, but the waves were only 16 ft. On the 10th, the HAWAIIAN MONARCH was south of the HIGH off Los Angeles with 43-kn northeasterly winds. Later in the day the AMERICAN ASTRONAUT was in the same area (33°N, 135°W) and found 57-kn winds.

By the 11th the eastern center had broken away from the main HIGH and was 1030 mb near 47°N, 136°W. The heat LOW split into two centers, one over Nevada and one over Mexico. The gradient slackened and the winds decreased.

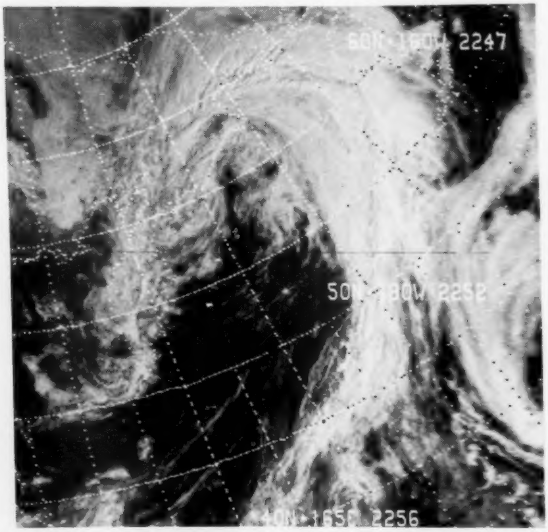


Figure 67.--The 962-mb storm is near 61°N, 177°E. The high winds were located under the frontal cloud shield.

This was the first significant extratropical cyclone for the month. It tracked across the U. S. S. R. and gained strength as it moved across the northern Sea of Okhotsk. At 0000 on the 12th it was 982 mb near 58°N, 160°E. The SOYOKAZE MARU was east of the occluded front with southerly 38-kn winds and 26-ft swells. Twenty-four hours later the pressure had fallen to 962 mb (fig. 67). The OHMINESAN MARU was over the central Bering Sea south of Saint Matthew Island with 40-kn southerly winds. Other ships south and east of the center were experiencing gales of about 35 kn. The GLACIER was southeast of Saint Matthew Island at 0600 on the 13th and radioed 47-kn southerly winds with 10-ft seas. On the 14th the LOW split into two centers as it crossed the Chukotskiy Peninsula.

Monster of the Month--A front over midocean pushed as far south as latitude 35°N on the 11th. It was accompanied by a sharp trough between two centers of the Pacific High. Several waves formed on the front and on the 12th one developed into a fair-sized LOW (fig. 68). Two ships, the KHERSONES west of the center and the ARIZONA MARU southwest of the 1002-mb center at 41°N, 167°W, were swamped by swells of 35 ft. The HIGH to the northeast expanded southwestward, and the LOW weakened and moved southward.

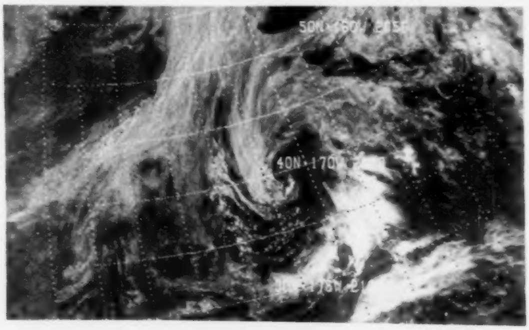


Figure 68.--The high-pressure centers were located near 47°N, 140°W, and 33°N, 155°E. The LOW is centered near 40°N, 170°W, with the primary front curving northeastward from the western side of the LOW with the inverted trough. The other extension of the front curves eastward north of the center and then sharply southward and westward.

The LOW was now associated with an inverted trough and a cutoff LOW aloft. It drifted westward in the vicinity of 35°N until late on the 17th when it turned northward as the upper air LOW again became associated with the zonal westerlies. On the 16th the TOYOTA MARU passed 400 mi north of the center and headed into 16-ft seas and 20-ft swells. At 0600 a ship far to the east of the LOW and between it and high pressure radioed 65-kn winds from the east.

On the 17th the 1006-mb LOW was centered near 34°N, 178°W. The TAIZAN MARU was 200 mi north of the centrr with 25-ft waves. By 1200 on the 19th the 992-mb LOW was at 47°N, 177°W. A Japanese-registered ship reported heavy rain, 40-kn winds, and 10-ft waves west of the center. On the 20th the PRESIDENT MCKINLEY experienced 40-kn winds with 18-ft waves in the northerly flow west of the storm. Another ship in the same quadrant had 20-ft waves. The VIOLET was at 45°N, 179°W, with 20-ft seas and 23-ft swells on the 21st. The storm was absorbed by a Gulf of Alaska LOW that same day.

The first chart to indicate the presence of this LOW was the 0000 chart on the 15th. The circulation was indicated by reports from the SHINANO MARU, OHMINESAN MARU, and Adak Island. The SHINANO MARU reported 50-kn winds from the west-northwest. By 0000 on the 16th, the 994-mb LOW was over western Alaska (fig. 69). The KASHIMA MARU was off the coast with 40-kn gales. A report from the MOBIL MERIDAN indicated 65-kn winds over the Gulf of Alaska. At 1200 the LOW was moving off the south coast of Alaska and the ARCO JUNEAU was fighting 20-ft swells. The NEWARK was headed toward Cook Inlet on the 17th with 40-kn winds from the northwest. By 1200 that day another LOW off Washington took over the circulation.

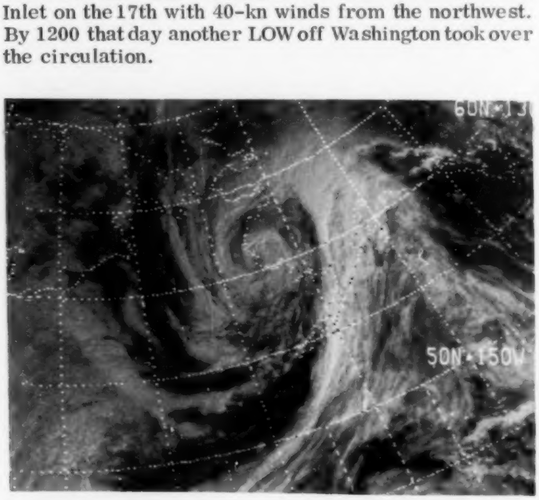


Figure 69.--The LOW is centered near Cape Romanzof with the more severe weather in the southerly flow over the Gulf of Alaska.

At 1200 on the 20th extratropical Emma was at 45°N, 152°E, about 300 mi east of Hokkaido. The CHIKUHO MARU was 200 mi southwest of the center with 45-kn winds and 36-ft swells. The JAPAN ACACIA was 150 mi southeast of the center also reporting winds of 45 kn but no seas in the observation. Twelve hours later

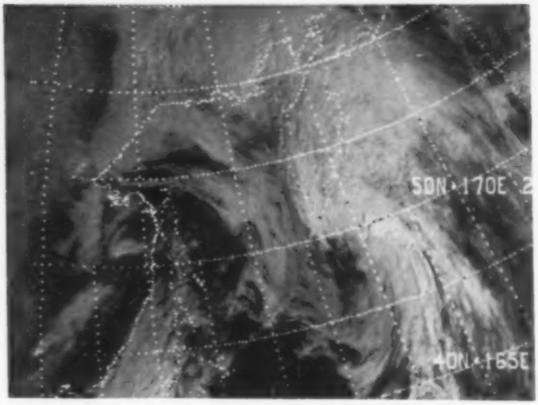


Figure 70.--At this time on the 20th, ex-Emma is near 50°N, 162°E. A line of thunderstorms appears to lead into the center from the south and southeast.

the ACACIA was still fighting 40 kn (fig. 70). Gale-force winds continued to blow, and at 0000 on the 23d the 962-mb storm was at 61°N, 170°E. The JUJU MARU reported 35-kn winds and 20-ft waves 600 mi south of the storm's center. It was now the largest extratropical cyclone of the month. Its circulation spread from Alaska well into Siberia and from the East Siberian Sea to 45°N. On the 23d land stations on the Chukotskiy Peninsula reported 35- and 40-kn winds. On the 24th the NORTH STAR III was in Kotzebue Sound with 45-kn southerly winds and 15-ft seas and swells. As the storm moved over the cold Chukchi Sea, it rapidly weakened but managed to survive until the 29th near 84°N.

As extratropical Emma moved across the eastern tip of Siberia she left a deep trough which paralleled the Kuril Islands. As the trough swung eastward, a LOW formed near 45°N, 161°E, on the 25th. Within a few hours it had broken its connection with the other circulation. By 1200 it was 986 mb near 47°N, 165°E. The NORWAY MARU was 100 mi south of the center with 992-mb pressure, 40-kn winds, and 15-ft swells. This was only a sample of what was to come (fig. 71).

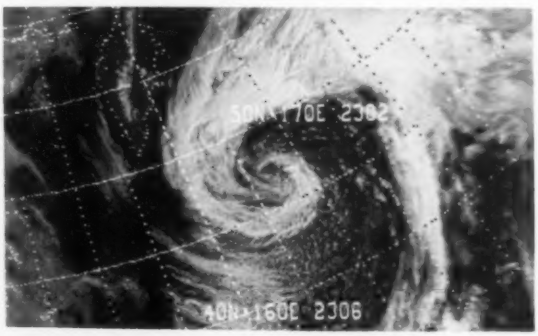


Figure 71.--The rapidly moving storm is near 48°N, 167°E, at 2300. The turbulent conditions in the southwest quadrant are indicated by the cumulus clouds.

On the 26th the PRESIDENT JEFFERSON was sailing with 45-kn gales with 30-ft swells on her stern. At least three other ships reported seas and swells up to 25 ft in the southwest quadrant of the storm. Six hours later she had 48-kn winds and 25-ft waves. The SEA-LAND FINANCE joined in with 38-kn winds and 20-ft seas in the vicinity of 45°N, 165°E. Winds of 40 kn and seas of 20 ft continued into the 28th. On the 28th the LOW broke up into multiple centers over Alaska.

Tropical Cyclones, Eastern Pacific--Short-lived tropical storm Emily formed on the 13th near 15°N, 118°W. She was just a minimal tropical storm as winds reached 35 kn during the 13th and early 14th. Emily tracked northwestward. By the time she reached the 20th parallel near 123°W on the 14th, her winds dropped below 25 kn. One week later Florence formed along the 15th parallel near 126°W. She headed northwestward but quickly turned toward the north-northeast. Winds near her center climbed to hurricane force by the 22d (fig. 72). The following day they

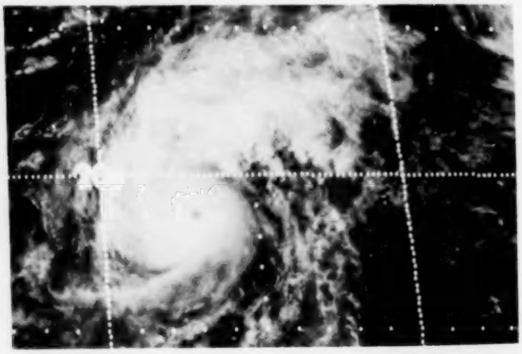


Figure 72.--The distinct eye of hurricane Florence is near 19°N, 127°W, at 2045 on the 22d. Tropical depression number 13 is west of Cape San Lazaro.

were blowing at 90 kn. It was at this time that tropical storm Glenda was detected some 150 mi east of Clipperton Island. Heading westward she passed just north of the Island on the 24th and then turned northward. Her winds were at a peak of about 40 kn. Meanwhile, Florence's winds had fallen back to tropical storm strength. By the 24th, after crossing the 25th parallel near 124°W, she was downgraded to a depression (fig. 73). Glenda fell to depression strength by the 25th after crossing the 15th parallel near 109°W. She turned northwestward and passed near Socorro Island. Some semblance of a circulation persisted until the 27th, when she finally dissipated after stalling on the 26th near 21°N, 114°W.

Tropical Cyclones, Western Pacific--Babe popped up among the Caroline Islands, near Woleai, on the 2d. The following day the South China Sea spawned Carla, midway between Luzon and Hainan. Both systems moved westward. Babe reached tropical storm strength on the 2d, while Carla climbed to tropical storm intensity on the 3d. Carla's winds never exceeded 35 kn as she moved south of Hainan and into Vietnam on the 4th.

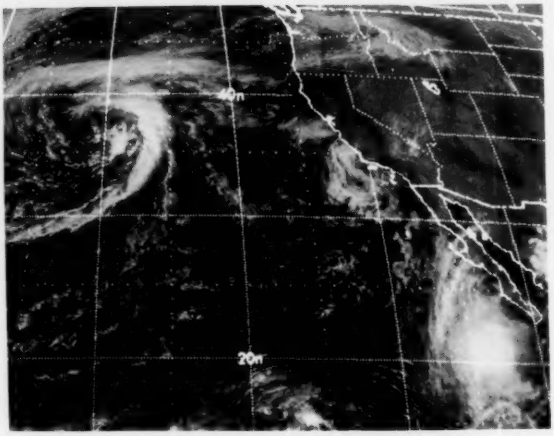


Figure 73.--Both tropical cyclones have been reduced to depression strength at midday on the 25th. Florence is near 37°N, 139°W, and Glenda, her circulation center covered by high clouds, is near 21°N, 113°W.

On the 5th the OHIAKI MARU, far to the north of Babe's center, ran into 20-ft swells in gale-force winds. That same day Babe turned toward the north. The following day she reached typhoon strength and shifted her course slightly to the west of north. Winds continued to climb and by the 8th, as she crossed the 20th parallel near 127°E, Babe reached supertyphoon strength as winds hit 130 kn. Early on the 9th (fig. 74) the GOND, GZWL, and 7JBU all encountered 30- to 35-ft swells in the eastern semicircle of the storm. Winds ranged from 50 to 64 kn. The powerful storm turned toward the north-northeast and banged through

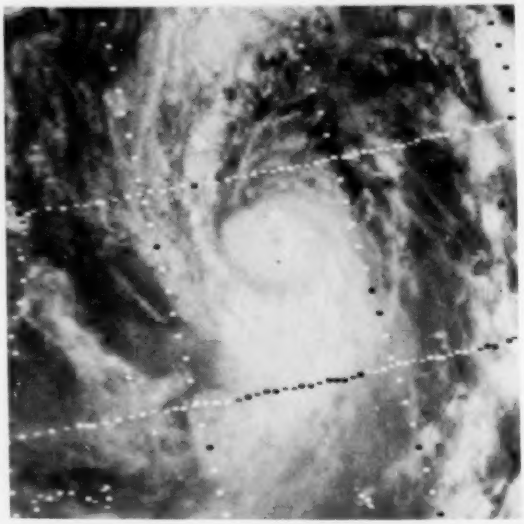


Figure 74.--Supertyphoon Babe was caught by the satellite at 0001 on the 9th as she tossed ships with waves reported up to 35 ft.

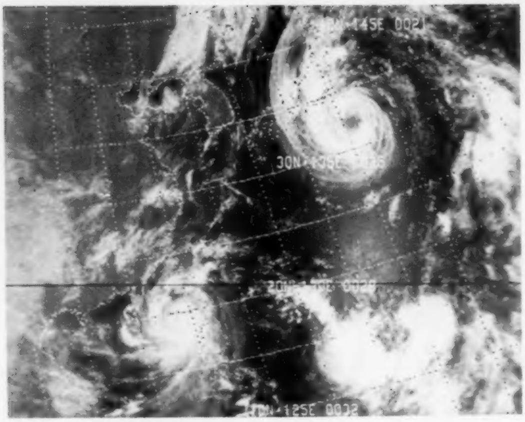


Figure 75.--Heavy rain from tropical storm Emma lashes Honshu while she is south of Tokyo on the 19th. Dinah is stalled south of Taiwan, and a depression is near 14°N, 138°E.

Figure 76.--Dinah has regained typhoon strength south of Taiwan by the 21st. Later she moved toward the southwest.

the Ryukyu Islands near Okinawa later in the day. While traversing the East China Sea on a northwestward then westward heading, Babe caused some problems. The MAY CRUISER, a Panamanian-registered freighter, radioed on the 10th that she was in danger of sinking in typhoon-lashed seas, about 250 mi northwest of Okinawa. Nine Filipino crewmen were rescued from lifeboats, thirteen were found dead, and three were missing. Early on the 11th still packing typhoon-force winds, Babe swept over the Chinese mainland near Shanghai. In the woods, Babe uprooted hundreds of trees while her heavy rains flooded the already waterlogged fields.

A tornado was reported in association with Babe in Japan at Fukuoka City on the 8th. Babe was responsible for one death and 77 injuries in Japan. A total of 1,106 houses were destroyed and 1,053 others heavily damaged in western Japan. Hardest hit was Okinoerabu Island, where winds of more than 40 kn blew for several hours. Rainfall totals as high as 10 in were recorded.

In mid-September Dinah and Emma developed at about the same latitude (21°N) but nearly 900 mi apart. Dinah was spotted on the 14th near 128°E and moved southwestward. Emma was detected early the following day near 143°E heading north-northeastward. By this time Dinah was intensifying as she approached landfall over northeastern Luzon. Dinah crossed Luzon as a typhoon with maximum winds of 70 kn. The rugged terrain took its toll, and she entered the South China Sea heading westward as a tropical storm on the 16th. The death toll stands at 45 with several people missing. Most of the deaths resulted from drownings. Meanwhile, tropical storm Emma was heading northward across the 25th parallel near 145°E. Emma maintained a circulation with maximum winds of 50 kn from the 16th until the 18th as she jogged northwestward then northeastward passing just east of Tokyo on the 19th (fig. 75). Emma brought torrential rains to Japan resulting in floods and landslides on Honshu. Up to 11 in of rain fell in some sections. Hardest hit was Fukushima Prefecture where four people were killed in landslides. Altogether, six people died, with two others missing. By the following day she was turning extratropical. Dinah had moved westward then, on the 17th, recurved toward the northeast. On the 18th the VISHVA TARANG ran into 60-kn winds about 150 mi south of the center, while the NISSAN MARU reported 56-kn southwesterlies closer to the center. The STRATHAPPIN and the SHOJU MARU encountered 20- to 28-ft swells in gale-force winds. From the 19th through the 21st she meandered near 20°N, 119°E, and regained her typhoon intensity (fig. 76). Peak winds reached 70 kn on the 20th. On the 21st she finally headed southwestward. Dinah's intensity began to wane; by the time she reached the central coast of Vietnam on the 23d, maximum winds had dropped to 50 kn.

While Dinah was dying over Vietnam Freda was coming to life off the coast of northwestern Luzon. The tropical storm moved west-northwestward. Maximum sustained winds reached 55 kn on the 24th, before Freda moved ashore over mainland China, about 100 mi southwest of Hong Kong.

Casualties--The barge GD-3 broke from its mooring during a storm on the 13th and 14th and hit the Dillingham Drydock. The dock was damaged and the barge ran aground.

Marine Weather Diary

NORTH ATLANTIC, DECEMBER

WEATHER. December is generally one of the stormiest months of the year over the North Atlantic, particularly north of 35°N. Deep and extensive LOWs traverse the middle and northern shipping lanes, producing strong winds and high seas. Extended periods of rain, sleet, or snow usually attend these storms. A comparison with the normal pressure pattern of the preceding month shows that in December the Azores High remains at about 1021 mb and is centered near 35°N, 33°W. The Icelandic Low deepens 1 mb to 1001 mb; it is located near 62°N, 38°W.

WINDS from the westerly quarter prevail over most of the ocean north of 40°N. Speeds average force 5 to 6 over most western and central waters, and about force 4 over the Bay of Biscay and surrounding waters, the Baltic Sea, and the southern portion of the North Sea. Force 5 to 6 southeasterlies prevail over the northern half of the North Sea, while southerlies of force 4 to 5 are predominant off the central coast of Norway. Winds over the Norwegian Sea are variable at about force 5. Between 40° and 30°N, winds (force 3 to 4) are westerly or southwesterly west of 20°W, northerly or northeasterly between 20°W and the Strait of Gibraltar, and predominantly westerly over the Mediterranean Sea. The "northeast trades," also averaging force 3 to 4, persist between 30° and 10°N, except off the east coast of Florida where winds are variable at force 4. As in November, force 3 southeasterlies prevail over the extreme southern North Atlantic.

GALES. The occurrence of gales is more frequent over northern and middle latitudes than in November. Winds of force 8 or higher occur 10 percent or more of the time from about 34°N over the western North Atlantic to about 40°N over eastern waters. A 10-percent frequency of gales is encountered on the Mediterranean Sea within an area extending nearly 200 mi southeastward from the Gulf of Lions. The incidence of gales is less than 10 percent over the immediate waters east of Newfoundland and over the Davis Strait. Areas of maximum gale frequency--20 percent or higher--are found within an area from the Labrador Sea southeastward to about 44°N, 35°W, then north-northwestward to 56°N, 40°W, then eastward to 55°N, 24°W, then north-northwestward again to the cold waters off southeast Greenland; over much of the Norwegian Sea; and over the Gulf of Lions.

EXTRATROPICAL STORMS. Two primary storm tracks--one from the waters east of the United States Middle Atlantic States and one from the northern Great Lakes--converge over Newfoundland and then head toward Greenland, where they split into two tracks with one leading into the Davis Strait and the other heading toward Iceland. A large number of LOWs also head toward Iceland from the central ocean east of 40°W and north of 50°N. Another cyclone track enters the Davis Strait from Hudson Bay, while still another runs across the northern coast of Norway from the Norwegian Sea. A primary track stretching from the Gulf of Lions to west-central Italy and then eastsoutheastward to the south coast of Turkey influences the Mediterranean area. The Great Lakes have their highest cyclone frequency of the year during December. The frequency of cyclogenesis over the Gulf of Mexico also reaches it annual maximum during December.

TROPICAL CYCLONES. There is seldom a tropical storm on the North Atlantic in December. During the 45-yr period, 1931-75, only two were recorded; one of these reached hurricane strength.

SEA HEIGHTS of 12 ft or higher occur 10 percent or more of the time north of a line extending from the northwest coast of Spain to approximately 35°N, 70°W, and then east of a line joining that point with Nova Scotia. On the Norwegian Sea, however, sea heights ≥ 12 ft usually occur less than 10 percent of the time. Ten-percent frequencies are also found in the Mediterranean between Balearic Islands, Sardinia, Tunisia, and the French Riviera; between Sicily and Crete; and on the northern Aegean Sea. Maximum frequencies of 30 percent or more occur over the Denmark Strait and over much of the western and central ocean north of about 47°N and south of the 60th parallel. An isolated area of 20-percent frequency rests over the Gulf of Lions.

VISIBILITY. The frequency of visibility less than 2 mi climbs to 10 percent over the Labrador Sea, over a pocket-shaped area extending from Kap Farvel southsouthwestward to the Grand Banks, over the southern and eastern Davis Strait, and over the southern North Sea. Frequencies of this low visibility are also greater than 10 percent over the area north of a line drawn from the Denmark Strait eastward across northern Iceland, then dipping southward to about 64°N, 7°W, then stretching north-northeastward over the Norwegian Sea, and then eastward to the northern coast of Norway. North of about 72°N, the frequency of visibility less than 2 mi increases to 20 percent and continues to increase as one moves eastward until, after reaching the southern Barents Sea north of the Soviet Union, frequencies reach a maximum of 40 to 50 percent.

NORTH PACIFIC, DECEMBER

WEATHER. December is usually a stormy month over North Pacific waters, particularly in the northern and middle latitudes. The normal pressure distribution is quite similar to that of the preceding month with the Aleutian Low (1001 mb) shifting to near southeastern Kamchatka.

WINDS north of 55°N blow mostly from a northerly direction at force 4 to 6, except over the Gulf of Alaska where force 4 easterlies prevail. Westerly winds of force 3 to 6 are usually felt south of 55°N to about 40°N over the extreme eastern ocean, 35°N over the central-eastern and midocean, and 30°N west of 165°E and east of Japan. Nevertheless, winds over the southwestern Bering Sea show a tendency to be variable, and off the coast of British Columbia the prevailing wind is southerly. Steady "northeast trades" prevail (force 4) between 25°N and the Equator, except

they extend to nearly 35°N off the southwestern California coast. These trade winds merge with the force 4 to 5 winds of the northeast winter monsoon near 140°E. Variable winds (force 3 to 4) lie in a narrow belt between the aforementioned westerlies and northeasterlies. Prevailing winds are largely from the north or northwest and average about force 4 over the Sea of Japan, and the Yellow Sea, and along the southeast coast of Japan. Northerly winds blow steadily out from the Gulf of Tehuantepec, off the south coast of Mexico.

GALES. A larger area of the North Pacific is subject to gales during December than in the preceding month. North of about 39°N over eastern and central waters and 32°N over western waters, 10 percent of the observations contain winds of force 8 or higher. The greatest frequencies, 20 to about 25 percent, occur in three scattered areas from the waters south of the southern tip of the Kamchatka Peninsula south-southeastward to about 34°N, 166°E. Farther north, the frequency of gales decreases to less than 10 percent over the Sea of Okhotsk and the Bering Sea. They are also under 10 percent across a triangularly shaped area southeast of the Aleutians bounded at 53°N, 162°W; 47°N, 163°W; and 49°N, 174°W. Gales are recorded between 5 and 10 percent of the time on the waters surrounding Taiwan, the southern Ryukyus, and the northern portion of Luzon as far east as 144°E, because of the strong development of the northeast monsoon. Gale-force northerly winds occur between 5 and 10 percent of the time out from the Gulf of Tehuantepec.

EXTRATROPICAL CYCLONES. Primary storm tracks extend from the northern portion of the Sea of Japan and the waters east of the Ryukyus to the ocean region lying between Kamchatka and the western Aleutians. From there, LOWs either pass near the Pribilof Islands or continue east-northeastward to the Gulf of Alaska. Another major storm track reaches the Gulf of Alaska from an area south of the Alaska Peninsula near 48°N. The only other primary cyclone track swings toward Vancouver Island from a point 450 mi west of the Oregon coast.

TROPICAL CYCLONES. One tropical storm usually develops over the western North Pacific during December. About two out of every three that do pop up go on to become typhoons. The most likely area of formation is in the neighborhood of the Caroline Islands. Contrary to the events of November, very few of these storms are able to maintain their identity over the South China Sea after traversing the Philippines.

Off the Mexican west coast, tropical cyclones are rare in December.

SEA HEIGHTS of at least 12 ft occur 10 percent or more of the time north of approximately 35°N, east of 150°E, and south of the Alaska mainland, the Aleutian Islands, Kamchatka, and 55°N on the Sea of Okhotsk.

VISIBILITY under 2 mi occurs 10 percent or more of the time north of a line drawn from the lower Tatar Strait to the central Kurils and then northeastward to the western Aleutians where it dips southeastward to about 47°N, 177°W. Upon reaching a point near 47°N, 165°W, the line bends generally northward to Cape Romanzof, Alaska. A much smaller area of 10-percent frequency is centered near 44°N, 143°W. Visibility less than 2 mi encompasses more than 20 percent of all observations poleward of a line cutting through the northern and eastern portions of the Sea of Okhotsk, the northern Kurils, and then northeastward through the Bering Sea to the Bering Strait (passing west of both the Komandorskiye Islands and St. Lawrence Island). A smaller area comprising a 20 percent or greater frequency lies north of the central Aleutians near 54°N, 173°W.

NORTH ATLANTIC, JANUARY

WEATHER. January is generally characterized by rough weather over the middle and northern latitudes of the North Atlantic. LOWs frequently become deep, and associated winds often reach gale and sometimes hurricane force. The Icelandic Low (1000 mb), centered off the extreme southeastern tip of Greenland, is deeper than at any other time of the year. The Azores-Bermuda High with a central pressure of about 1023 mb covers a band from the western Mediterranean Sea west-southwestward to the waters northeast of the Bahamas.

WINDS. North of 40°N, the prevailing winds are westerly over most of the ocean. Over the Norwegian Sea and the North Sea, winds from the southerly quarter prevail. The average wind speeds are predominantly force 4 to 6, except up to 1,200 mi south and east of the southern tip of Greenland and over the Labrador Sea where they reach force 5 to 7. Between 25° and 40°N, the wind direction is from the southwest quarter of the compass over the main body of that portion of the Atlantic, mostly easterly over the Gulf of Mexico, variable over the waters east of Florida, and northerly or northeasterly from west of the Iberian Peninsula to the Canary Islands. Westerlies still dominate over the Mediterranean Sea. Force 3 to 4 winds are the most common except off the coast of the middle Atlantic United States where force 4 to 6 winds prevail. From the Equator to 25°N, the "northeast trades" persist; more than 65 percent of the time wind speeds range from force 3 to 5, except south of 10°N where these winds blow more than 50 percent of the time.

GALES (winds force 8 and higher) occur in 10 percent or more of the observations north of 35°N over the western part of the ocean and north of 40°N over the eastern part. The Mediterranean Sea hosts 10-percent frequencies out to 150 mi from the Gulf of Lions, over the northern Adriatic Sea, and over most of the Aegean Sea. The highest frequency over all North Atlantic waters, 30 percent, is found over a small area centered at about 58°N, 30°W, over a narrow belt off the southern tip of Greenland between 38° and 52°W, and (because of the mistral) over the Gulf of Lions.

EXTRATROPICAL CYCLONES. During the winter months (December, January, and February) LOWs form most frequently in a band 150 to 250 mi wide stretching from the North Carolina-South Carolina border northeastward to about the latitude of Cape Cod. This is part of a large area of cyclogenesis that extends from the Gulf coast of the United States northeastward to the Bay of Fundy. Other principal areas

of cyclogenesis lie over the western half of the central ocean between Newfoundland and the British Isles, over most Icelandic coastal waters, over the inland waters east of the North Sea except the Gulf of Bothnia, and over the Mediterranean from the Gulf of Lions southeastward to the toe of Italy and then northward to the Yugoslavia coast. Cyclogenesis is more concentrated around the waters on both sides of central Italy than anywhere on the North Atlantic during winter with the exception of the band off the United States Atlantic coast. In January, primary storm tracks run from the Carolina capes to Cape Race and from Lake Superior to Cape Bauld. After reaching Newfoundland, cyclones either head northward to the Davis Strait or the Denmark Strait or northeastward to Iceland. Primary storm tracks are also present off the northern Norwegian coast, over the Mediterranean from the Gulf of Genoa to Cyprus, and over the eastern Great Lakes where they join the track toward Newfoundland.

SEA HEIGHTS greater than 12 ft occur 10 percent or more of the time north of 33°N over the western North Atlantic and north of 42°N over eastern waters. Frequencies greater than 10 percent also exist in a small area near Barranquilla, Colombia, and on the Mediterranean between Menorca and Sicily (not including the waters surrounding Corsica), south of Greece and west of Crete, and on the northern Aegean Sea. A large area of frequencies greater than 30 percent stretches from south of Iceland to west of Ireland to east of the Grand Banks and then northward to the waters southwest of Greenland and south of the waters between Greenland and Iceland. Smaller areas of similar frequency are found on the Denmark Strait and west of northern Norway near 67°N, 10°E. The frequency of sea heights greater than or equal to 12 ft decreases to less than 10 percent over a large portion of the Norwegian Sea north of 67°N between 5°E and about 13°W.

VISIBILITY less than 2 mi is noted in more than 10 percent of the observations from Cape Sable eastward to the Grand Banks and northward to Cape Mercy, over the Denmark Strait and the northwestern portion of the Norwegian Sea, and over the southern portion of the North Sea. The frequency increases to more than 20 percent in the Resolution Island area and over the Norwegian Sea north of about 70°N.

NORTH PACIFIC, JANUARY

WEATHER. The most severe weather of the year occurs generally in January over the middle and northern latitudes of the North Pacific. The circulation over the ocean is controlled mainly by the major centers of action--the Aleutian Low, the subtropical High, and the Siberian High. All except the subtropical High are near or at their peak seasonal development. The Aleutian Low, with a central pressure of 1000 mb, is southeast of Kamchatka near 50°N, 165°E, while the axis of the Pacific subtropical ridge exceeds 1021 mb from about 30°N, 135°W, east-northeastward to the State of Wyoming. The wind regime near the Asiatic coast from the Korea Peninsula to the South China Sea is controlled principally by the clockwise flow around the Siberian High (1036 mb), situated over Asia near 49°N, 96°E.

WINDS. Westerly winds prevail over much of the ocean north of 30°N and west of 180°. Northerly winds dominate the East China Sea. Winds are variable over the western Aleutians, southeasterly over the central Aleutians, and northeasterly near the Pribilof Islands. From the Gulf of Alaska southward to near 40°N and east of 180°, winds are mostly westerly to southerly, although other directions are common during the frequent passage of LOWs. Over the extreme northern Gulf of Alaska, the prevailing winds are easterly, and northerly winds are very pronounced over the Bering Sea north of 60°N. The average speed of winds north of 30°N is force 4 to 6, although southeast of Kamchatka the wind blows at force 7, 21 percent of the time. The "northeast trades" extend northward to near 25°N over most of the western and central ocean and to 30°N over eastern waters; south of 20°N, these winds are very steady. The wind speeds in the trades range from force 3 to 5. The "northeast monsoon" is steady over the South China Sea and the Philippine Sea south of 30°N and west of 150°E. Winds are quite variable over the eastern North Pacific between 30° and 40°N, southwesterly over the east-central ocean between 25° and 40°N, and variable over west-central waters between 25° and 30°N and 150°E and 180°. Wind speeds over the above three areas are usually force 4. Northerly winds predominate over the Gulf of Tehuantepec, and in 65 percent of the observations they range between force 2 and 6.

GALES. The frequency of gales near and above 10 percent affects most noncoastal areas south of the Aleutians and north of a line from the waters southeast of Honshu to a point south of the Queen Charlotte Islands and west of Washington State. A maximum incidence of over 20 percent is found over a relatively large region southeast of Kamchatka, over a smaller area east of northern Honshu near 39°N, 154°E, and south of the Gulf of Alaska near 50°N, 145°W. Gale-force northerly winds are encountered more than 10 percent of the time by vessels plying the Gulf of Tehuantepec off southern Mexico. These violent squally winds occur when strong northers from the Gulf of Mexico funnel across the isthmus to the Pacific. In extreme cases, they may be felt more than 200 mi out at sea.

EXTRATROPICAL CYCLONES. Principal areas of cyclogenesis during winter are found from Taiwan on the southwest to the northern Kurils and lower Sakhalin on the northeast and from just north of Marcus Island on the southeast to the western shore of the Sea of Japan on the northwest. The Yellow Sea and Korean coastal waters are not included in this vast region of cyclogenesis. Other smaller areas of cyclogenesis lie over the Pribilof Islands, the Gulf of Alaska, off the North American coast from the Queen Charlotte Islands southward to northern California, and over the east-central ocean about midway between the Aleutian and the Hawaiian Islands. The migratory LOWs move mostly northeastward from the East China Sea and Hokkaido to the western Aleutians and then east-northeastward to the Gulf of Alaska. Other primary tracks approach the Gulf of Alaska and Vancouver Island from the southwest.

TROPICAL STORMS are infrequent in January. On the average, two can be expected every 5 yr over the western North Pacific. Most of these storms develop between 6° and 10°N and west of 150°E and move toward the southern half of the Philippines. Three out of every five January tropical storms achieve typhoon strength.

SEA HEIGHTS greater than 12 ft occur more than 10 percent of the time in an area extending northward from 30° to 35°N to a line drawn from Kodiak Island to the central Aleutians and then to the southeastern waters of the Sea of Okhotsk, and westward from a line 700 mi off the coast of southeastern Alaska and 500 mi off the Oregon coast to 150°E.

VISIBILITY less than 2 mi occurs in 10 percent or more of the observations over an area of the eastern North Pacific between 40° and 50°N and 141° and 162°W, and northwest of a line drawn from Hokkaido to the western Aleutians and then northeastward along the Aleutian chain to the Alaska Peninsula and Cape Avinof. A maximum frequency of over 30 percent encloses a small area over the Okhotsk Basin southwest of Kamchatka.

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